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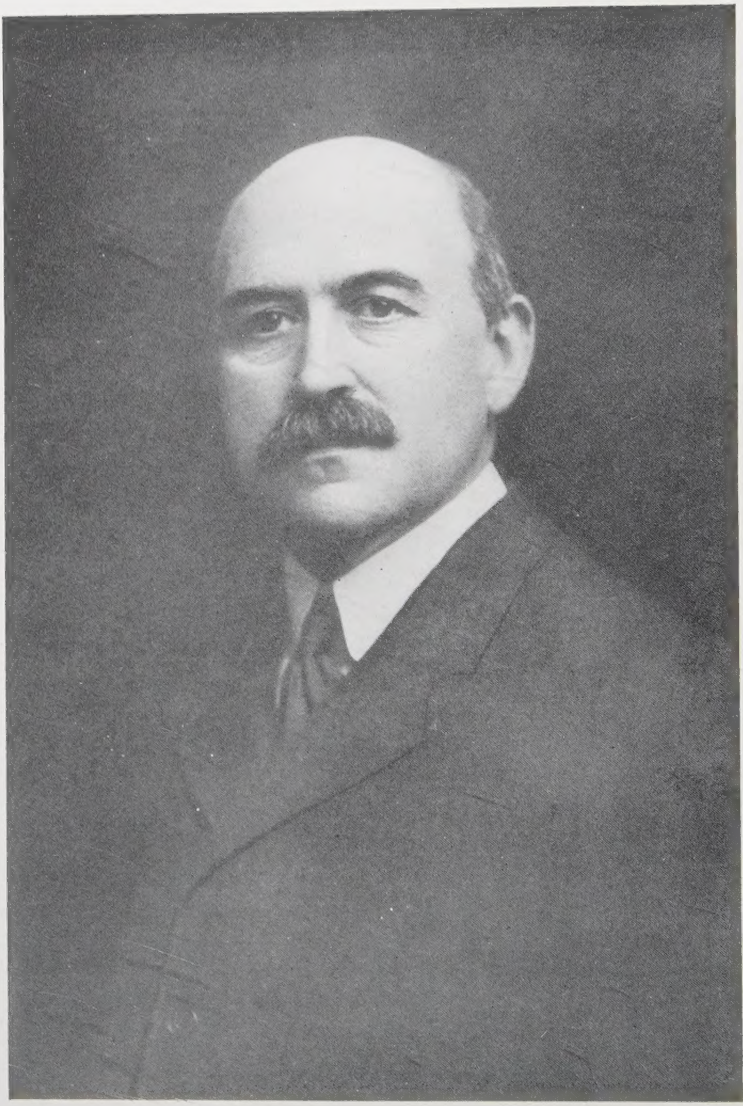

Wm Bullock Clark

NATIONAL ACADEMY OF SCIENCES
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BIOGRAPHICAL MEMOIR

OF

WILLIAM BULLOCK CLARK

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BY

JOHN M. CLARKE

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the Connecticut and to Brattleboro came Dr. Clark's immediate progenitors, and there he was born—a son of a substantial and respected father and of a strong-hearted mother. Obedient to the recognized procedure of heredity, Dr. Clark is said to have derived much of his intellectual vigor and agility from his mother; but it would be beyond my power or wish to think of Dr. Clark or to present him to others as a composite of ancestral traits; rather as a unit of character and work.

In the home at Brattleboro there were influences indoors of the Christian fireside and outdoors of the attractiveness of the river and its bounding hills. There, too, was the busy industry of the town, with its commercial ambitions. One may perhaps find it possible to trace back into some of this youthful environment the threads which were to be woven into the manhood fabric; yet, after all, the boy lived a normal, healthy Yankee boy's life, and as schooling days in Brattleboro drew to a close was, like other Yankee boys, possessed with the desire to go to college. I have learned of no special proclivities toward geology which Clark had acquired from the granite hills and river clays of Brattleboro; but I have learned over and over again that in the making of a boy into a man there is some one individual's influence that is likely to dominate all others, leave a deep imprint, and often turn the feet into a determined path. So I think we may say of Dr. Clark, as I once had occasion to say of his predecessor at the Johns Hopkins, there was nothing startling, premonitory, or out of the ordinary in his school and college career; but that, always a good student, leaving behind a reputable record, he was not awakened to a real purpose in life until he was led into the circle of the sciences which are concentric to geology; and this was in Amherst College and the torch-bearer was then, as before and since, Professor Benjamin K. Emerson.

A singular physiology determined the direction of Clark's career in geology. Professor Emerson was then in a quartan fever of enthusiasm over the new petrology and was keenly disposed to induct his students into its fascinations; but as it happened Clark was, in a moderate degree, color-blind and the nicest discriminations of the crossed nicols were not for his eyes; so perforce his efforts were directed into the standard lines of geology—structure, stratigraphy, and paleontology. It was for the pursuit of these aspects of his science, colorless in a certain sense, but vastly colorful in their chief reactions, that on graduation in 1884 he left Amherst for Europe with the inspiring companionship of Professor Emerson and Professor William North Rice, both of whom were going off together for a year's holiday. This was such an opportunity for travel and uplifting fellowship as seldom falls to a young man's lot. In journeys through Scotland and down into Cornwall and Devonshire, up the Rhine and into Switzerland, their scenery and geology expounded by his extraordinary couriers, amid the exciting surroundings of new lands, the student was electrified by the allurements of his science. Everywhere he made notes and collected specimens, meanwhile conning his vade-mecum—Dana's *Manual.* Professor Emerson intimates that on this trip Clark was unfailingly thoughtful of the whimsies of the distinguished zealots who were acting as his spiritual guides.

Arriving at Munich, he was advised to settle down and study with Zittel, then the leading paleontologist active in the universities of Central Europe. There, and also for a short time at Berlin, he had the experience which so many American students of those days shared; an opportunity to acquire the precision of German procedure while, like others, he unwittingly succumbed to the ingratiating propaganda of Teutonic national ideals. As Munich was in the heart of a region where the Mesozoic and Tertiary rocks were richly developed, Clark's special interest was turned in their direction, and he always afterward pursued, by preference, investigations in this field.

Prof. George Huntington Williams, then at the head of the newly organized Department of Geology at the Johns Hopkins University, wholly enamored of the Zirkel-Rosenbusch petrology, a scholarly investigator of the best type after the German model, felt the need of assistance in the organic phase of geology, and through him Dr. Clark, who had made his degree at Munich, was invited to that institution which through the rest of his life was to be the stage and setting of his successful career.

Memorial tributes in other places have dwelt upon the growth of Dr. Clark's influence in the university, and there is today a widespread cloud of witnesses to his successful labors in the scientific army of this nation. So we may perhaps wisely summarize the university phase of his life in a few paragraphs.

It is the misfortune of a teacher's career that it cannot be defined in terms of the influences it imparts. The portrait must always fail in some intangible measure when it is drawn in words alone. A student's memories and the influence for good which he in his day transmits are the most subtle and doubtless the most enduring of all tributes to a successful teacher, and these we may leave to the generations of his disciples. Williams and Clark were a strong team at the Hopkins; Williams, the erudite and polished scholar, refined in research, hesitating a little to step down to the street from his cloister; Clark, with a big heart open to all men, eager to carry his message and his science to all the people, a splendid mixer and propagandist, with an unwearied enthusiasm for ever more work and a genius for organization. When, in the vicissitude of life, Clark took charge of the department, he brought into it a spirit of living emulation and freer interchange. The ascetic cells were none the less regarded, but their devotees were turned out for frequent airing, made to meet the man on the street and understand his claim upon them. Professor Clark strengthened his own hands immensely in the wise choice of his strong associates in academic work; Mathews, the sturdy, clear-headed geologist and executive; Reid, the fine-strained, acute geophysicist; Swartz, the versatile teacher; Berry, the animating expositor of these academic groves.

The students who gathered around him caught his ideals; there was to be no specializing among them till they had covered the entire broad field of the science, organic and inorganic, and were then in some more adequate measure inoculated with his vision. That this paleontologist graduated from his department geologists, paleontologists, paleobotanists, geophysicists, highway engineers, and meteorologists was a natural realization of his proper university business; but a more vivid expression of his earnest conviction that geology is an essential science is the fact that he had convinced the engineering faculty of the imperative need of the full undergraduate course in geology for candidates in civil engineering.

Professor Clark became head of his department in 1894, but before he had reached this position he had contracted an affiliation with the U. S. Geological Survey which gave him an official standing therewith, and this in variant form was continued to his death. It was a connection extending over almost thirty years, from 1888 to 1917, and it had a very important influence on his life work in opening to his study, and in large measure to his eventual official control, the problems of the Cretaceous and Tertiary formations of the Atlantic Coastal Plain. Correlation in stratigraphy and paleontology in this region was vastly obscure at the time Clark began his work. The lamented McGee, with an unerring genius, had pointed the way out of the chaos of accumulated discrete data; but it is safe, I think, to say that in this field the work of many hands, guided by or coöperating with Dr. Clark, has brought to the science not alone a resolution of the outstanding problems, but a detailed and applied knowledge of practical resources before unknown.

In 1892, while still holding a subordinate position in the university, he made his first trial of outside organization and brought into existence the Maryland State Weather Service, of which he was made Director and as such continued until his death. A deeply interested and experienced student of climatology has characterized Clark's weather reports as the best ever made in this country.

In 1896, now with all his influence of a full professor in the Hopkins, he effected the creation of the Maryland Geological Survey, receiving the official title of State Geologist and safeguarding the organization by the creation of a Board of *ex officio* commissioners, of whose sympathy and support he might under all conditions feel reasonably secure. To such sympathetic and understanding support the noteworthy product of this Survey in no small way is due. It is almost needless to say that this organization, of all his creations, lay nearest his heart and that its volumes are his most tangible monument. Perhaps it is true that only those who have been charged with State geological surveys can fully appreciate the quality of this achievement, that is to say, only such men as have been confronted by similar problems in the effective manning of such a survey; the execution of essential details, the presentation of them to the public in inviting form, the whole mechanical paraphernalia thereto attached, and, of course, of prime moment, the securing of appropriations in such form and amount as to make the work free of embarrassing interruption. I believe it fair to say that the impulse toward the organization of this Survey may have begun to take form from the time Professor Williams and Dr. Clark were called on to prepare a treatise on the Geology and Mineral Resources of Maryland for the use of the World's Fair Commission in 1893. This document was of such broad and general scope as to summarize not only the outstanding knowledge, but the outstanding lack of knowledge as well.

The first official volume of reports on the Geological Survey was not issued till 1897, and naturally it was given over to a presentation of the general field, the history of such scientific investigations in the State, and the scope and importance of the problems involved in the undertaking. The first report of a newly created official departure is awaited with a critical keenness by the tax-payers, and the prescient Clark knew that the fate of his organization largely hung on the reception of his maiden volume; so he gave them an untechnical, readable book whose mechanical execution was worked out in the very best taste, with miniature geological maps rendered with a beauty of execution we had not seen before, carefully selected paper and letter-press, a dignified format and binding, the whole making a most attractive and desirable book. So his people estimated it, for its reception was laudatory and encouraging; and so his colleagues have estimated it in terms of the worldly wisdom which took this way to open the door to the technical volumes which followed. There are now ten volumes in this series, the last of which Dr. Clark's eye never saw. They are familiar to all of us geologists and they make a sumptuous array of varied and inviting books—the compendium, now that they have run through the gamut of the formations, of the economic, stratigraphic, and paleontologic facts of the State of Maryland.

Into this fruitful survey of his adopted State he brought a battalion of collaborators and independent workers. It may be said that he subsidized the best talent he could find for these geological problems, and it would be a long and strong list if I should here call the roll of these shareholders. If one should say, herein lay his good generalship, that he could impress so many to his service, and that a too ponderable share of the load was laid upon the shoulders of his effective aides, let this critic look through the contents of these volumes and learn the very large part which Dr. Clark's own hand has played in the creation of their technical contents.

No sooner was the geological organization on its feet and fortified by the plaudits with which its first volume was greeted than Clark took advantage of the good-roads propaganda, which was then spreading through the Eastern States, to organize a Highway Division of the Geological Survey. The construction of a system of public highways for a Commonwealth calls for executive ability of the first order. It must commandeer high-grade engineering, prudent financiering, and astute appreciation of community and commercial requirements and avoid the emaciated political sniper. It also takes money in great sums. From 1898 to 1910, after an expenditure of $2,000,000, when the importance of the work made necessary the organization of a separate board—the Maryland State Roads Commission—these activities were carried on by the Geological Survey, and their successful appeal to the people greatly strengthened the organization, perhaps in such degree that it was freer to stroll away among the aisles of pure science, from which during this period emanated so many of the volumes on paleontology.

"The fine roads that now run through Maryland counties are in no small measure the result of his sound advice and far-seeing counsel," said the *Baltimore American*, in commenting on the death of this "most useful citizen."

Professor Clark was made a member of the new commission, and so continued until 1914.

Ten years ago the problems of forest protection and development were subtending a large angle in the public vision, and at that time Dr. Clark was made executive officer of the Maryland State Board of Forestry, and with the parturition of the term *conservation* at the celebrated "Governors' Meeting," called by President Roosevelt at the White House, and, as one might say, the "pinchoting" of "conservation commissions" over the land, Clark was appointed by the Governor a member of Maryland's Commission.

The foregoing may be taken as the summary, or rather as an inventory, of Professor Clark's scientific activities; in them all he showed the initiative of the pioneer, I think an inherited trait. His ancestors "pioneered" from England to Plymouth; from Plymouth to the mouth of the Connecticut; from there to Brattleboro; then he "pioneered" from Brattleboro to Baltimore, where the atavistic geographical sense of organization seems to have been converted into the initiative for organization. But the scientific side of his life is only a part of his story. He entered without reserve into a man's share of civic life and duty and his competency to serve was recognized both by State and city. By act of legislature he was made Commissioner for the State of Maryland in the resurvey of the Mason and Dixon line. The Mayor of Baltimore, Mr. McLane, after the great fire of 1904, made him a member of a committee to rehabilitate the burnt district, and in that work he served as vice-chairman of the Subcommittee on Streets, Parks, and Docks; and I recall the proper pride with which he pointed out to me on one occasion the improvements which resulted from these labors. By Mayor Timanus he was appointed a member of a Commission on City Improvements and he was one of the first advocates of the present system of sewers. Again he was made a member of the Mayor's Committee to widen the down-town streets and create a civic center for the city. From 1901 to his death he was president of the Henry Watson Children's Aid Society of Baltimore, and this interest led him into a deep concern for problems relating to the dependent child, in which his judgment was so highly regarded that he was a delegate to the White House conference on this theme in 1909. He was also a member of the State Tuberculosis Association and vice-president and chairman of the Executive Committee of the Federated Charities of Baltimore.

Thus he gained esteem and confidence among his neighbors, the citizens of his vicinity—not an easy thing for a man of science, who is so freely condemned as "unpractical" by the so-called man of affairs. And these many lines of civic industry he carried without friction or loss of tone and never to an interference with his scientific labors and ambitions.

To enumerate the marks of appreciation of his scientific work would make a long list. I am not sure that Dr. Clark ever kept a complete one, but these were the progressive orders of his advancement: he belonged to American, English, and German geological societies; he was a member of the National Academy of Sciences and chairman of its geological section; of the American Philosophical Society; president of the Association of American Geologists; the treasurer of the Geological Society of America.

A few years ago, when Dr. William M. Davis was about to retire from the Sturgis-Hooper Professorship of Geology at Harvard, Clark was asked by Professor Davis and President Lowell to take the position. He was attracted by the offer. The venerable prestige of Cambridge, the large opportunity of expansion, the cozy repute of such an attachment, together with a certain pious genealogical appeal, made a strong argument to him; but the child of his creation was dearer to him than any child of adoption could be. He came to Albany to talk the matter out with me, and I was told afterward, when he had decided not to go, that the only condition of his remaining which he asked of his trustees was that the salaries of his colleagues should be increased.

Doctor Clark was an LL. D. of Amherst College, and probably might have been its president had he been so disposed. His administrative relations to the Johns Hopkins University during the interregnum after the retirement of President Remsen were so influential that many eyes were turned on him as a probable successor to the vacant chair. R. Brent Keyser, President of the Trustees of the Hopkins, speaking at Dr. Clark's public memorial,* has said of this: He "was among the first to be mentioned to fill the vacant position. I therefore asked him frankly for his attitude in regard to presidents, and he replied that while he appreciated fully the opportunities, honor, and dignity of the position, he was convinced that the university wanted a man outside of the faculty;

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*Held at the university, November 5, 1917.

and he at once threw himself whole-heartedly into the search for the outside man. In all matters in which the university was involved," added President Keyser, "he occupied the dual position of the man keen after its material prosperity, but even keener to guard its spiritual ideals."

Dr. Clark traveled widely, both in the far-flung excursions of the international geological congresses and with his family on many occasions. For many years he had made a summer home at North Haven, Me., and in his outings during vacation days at "Stonecrop" he threw his official cares aside and was always the wholesome, hospitable man-boy, bubbling with energy, gardening, raising chickens, building boats and sailing them, reveling in unchecked return to the instincts of Brattleboro days.

Doctor Clark married Ellen Clarke Strong, daughter of the late Edward A. Strong, of Boston, and descendant of William Clarke, of Dorchester (1637) and Northampton; and their four children, Edward, Helen (Mrs. H. Findlay French), Atherton, and Marion, share an unsullied strain of Puritan descent.

Thus, briefly, we have summoned together for this sketch the outstanding facts of Dr. Clark's life. Much of his record must remain untranscribed except upon the hearts of those who received his impulses and his confidences.

For some time before his death a heightening blood pressure had warned Dr. Clark of dangers ahead, but his undiminished vitality seems to have made him indifferent to the signal. In the spring of 1917 he was appointed to the Geology Committee of the National Research Council on nomination from the National Academy of Sciences and was asked to take over the organization of a plan which would locate, chart, and describe the entire supply of materials available for rapid highway and fortification construction from Maine to Texas and for 100 miles back of the seaboard. He entered on this undertaking with his customary energy, even though at the time serving as a member of the Maryland State Defense Council, and he effected a large and efficiently coöperating organization of about fifty geologists and highway engineers. This was his chief service for the war and he fell in the midst of it. Other hands have with prudence and efficacy brought the work to its completion, and it will stand as his last monument and a permanent memorial.

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Arnold Hague

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OF

ARNOLD HAGUE

1840-1917

BY

JOSEPH P. IDDINGS

PRESENTED TO THE ACADEMY AT THE ANNUAL MEETING, 1919

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ARNOLD HAGUE*

1840-1917

BY JOSEPH P. IDDINGS

ARNOLD HAGUE was born in Boston, Mass., on the 3d of December, 1840. His father, Rev. Dr. William Hague, was a Baptist minister, as was also his great-great-grandfather, William Hague, who was active in his pulpit at the age of 85, in his home in Scarborough, England. William Hague, the father of Arnold, was born near Pelham Manor, New Rochelle, N. Y., being a descendant, on the maternal side, of a Huguenot family which left France for Martinique, and later moved to New York State, and settled in the place afterward called New Rochelle. He was also descended from David Nimham, a North American Indian, who acted as guide for Washington's troops through the forests of Westchester, N. Y. Arnold Hague's mother was Mary Bowditch Moriarty, of Salem, Mass., a granddaughter of Deborah Bowditch and a relative of Nathaniel Bowditch, the mathematician. The family lived in Salem for three or four generations.

When Arnold was twelve years of age the family moved to Albany, N. Y., where his father was pastor of the North Pearl Street Baptist Church. In Albany Arnold attended the Albany Boys' Academy, from which he graduated in 1854, in his fourteenth year. He frequently attended meetings of the State legislature and took an interest in their proceedings, so that with a number of boy friends he took part in an amateur senate of their own and discussed questions that were interesting from the boys' point of view. In 1856 his father took the family to New York City, where he was instrumental in the erection of the Madison Avenue Baptist Church. During the next few years Arnold prepared himself for college, though a business career had been urged upon him against his inclinations, and in the autumn of 1861, when the Civil War was in its early stages and he had failed to be accepted as a volunteer for physical reasons, he entered the Sheffield Scientific School of Yale at the age of 20. Having been admitted with advanced standing, he took up the studies of junior year in what was known as the chemical course, there being at that time only two others—the engineering and the general course. Chemistry was taught by John Porter and Samuel W. Johnson, with O. D. Allen and Peter Collier as assistants. Metallurgy and mineralogy were taught by George J. Brush; geology by James D. Dana, and modern languages by William D. Whitney. Theodore Woolsey was the President of Yale at that time. The attendance in college was so greatly affected by the war that Hague's class, which graduated in 1863, contained only four students; so that each student undoubtedly received very direct personal attention from his instructor, and one may imagine the inspiration which the student, Hague, must have derived from such men as Dana, Brush, and Johnson.

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* This memoir is enlarged from a biographical sketch of Mr. Hague prepared by the writer for the Geological Society of America.

When Arnold Hague entered the scientific school Clarence King was in the senior class and O. C. Marsh was a graduate student, having graduated from the college in 1860 with the degree of A. B. and taking up courses in chemistry, mineralogy, and paleontology. Other students with whom Hague was associated, who were in the graduate school at that time, were J. Willard Gibbs and Ellsworth Daggett, who became a mining engineer. The acquaintance which began in this way with King and Marsh was destined to play a great rôle in the future life of Arnold Hague, especially the friendship with Clarence King; for while there is no record of Hague's experiences and aspirations during his college life, it is evident from subsequent events that the friendship for these two men influenced very much of his life's work.

After graduation, in 1863, with the degree of Ph. B., he again tried to enlist in the army and was rejected because of general physical deficiencies, when he determined not to remain in the country and went to Germany with a cousin, Lyman Nichols, spending a year in Göttingen familiarizing himself with the language and overcoming a defect of speech which had been a source of embarrassment to him. The following year he studied in Heidelberg, in Bunsen's laboratory, where most of his time was devoted to chemistry and mineralogy. In 1851, after a trip to Iceland, Bunsen had suggested the hypothesis of a pyroxenic, or basaltic, magma and a feldspathic, or trachytic, magma as the sources of all intermediate volcanic rocks, which it was assumed might be formed by their mixture during eruption; and it is to be supposed that Hague became acquainted with this idea directly from Bunsen, which might account for the hold this hypothesis had on him in later years as is shown in his discussion of the volcanic rocks of the Eureka district, Nevada.

At the end of his second year in Germany he again applied to enter the army service, saying he was entirely well and strong and felt an obligation to return. In reply he received a personal message from President Lincoln, saying in effect: "Stay where you are; we shall need such as you later." In the spring of 1865 he went to the Bergakademie, in Freiberg, Saxony, where he met S. F. Emmons for the first time, who had been there the previous year. This was the beginning of another friendship which was to continue throughout life and was to influence the careers of both these embryo geologists who were within four months of the same age. Emmons, having had a year's experience at the Bergakademie, became the adviser of Hague as to his best course and joined him in all the week-end excursions with von Cotta. They visited many parts of Saxony and studied petrology according to von Cotta's text-book. Their evenings were often spent studying the geological map of Saxony and in acquiring their first experience in geological cartography. In a reference to this experience Hague has said: "Both came to realize the influence of Cotta upon our future careers, as he gave us much of his time." *

Bernhard von Cotta was the author of a text-book on petrography, "Die Gesteinslehre," the second edition of which was published in 1862, and this book became Hague's guide and basis of petrography. In it all rocks were classified according

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* Hague, A. Biographical Memoir of Samuel Franklin Emmons. National Academy of Sciences, vol. 7, 1913, p. 315.

to mode of origin, as eruptive, metamorphic, or sedimentary; and eruptive rocks were divided into two groups on a chemical basis: 1. Those poor in silica, or basic; 2. Those highly siliceous, or acid. Each group was divided further into volcanic and plutonic. The separation into basic and acid appears to have been made with Bunsen's two-magma hypothesis in mind, but not as a direct expression of it, for von Cotta, in 1858, had proposed the hypothesis that the solid crust of the earth consisted of highly siliceous substances, and that the fluid portion beneath had about the composition of the most basic rocks, and that the variations in composition of eruptive rocks were due to the variable amounts of the solid siliceous crust which was taken up by the basic magma during its passage toward the surface of the earth.

Although Clifton Sorby had made the first use of the microscope in studying sections of rocks in 1851, and Zirkel had published microscopical descriptions of rocks in 1863 and 1864, the application of the microscope to petrography had not attracted any attention when Arnold Hague was preparing himself for his geological career. It was not until seven years after his return to this country that microscopical petrography began to attract general attention among geologists.

In December, 1866, Hague returned to his home, which was now in Boston, Mass. He was just 26 years old and had had a liberal education in chemistry, mineralogy, petrography, and geology as they were taught in those days. A few weeks after his return he met Clarence King in New York, and had a chance to learn from him his plans for a geological survey across the western cordilleras along the line of the proposed transcontinental railroad. One who knew King in later life can imagine the enthusiasm with which, at the age of 25, he must have described this enterprise and the romance with which he must have enveloped it. He offered Hague a position as assistant geologist if the proposed plan for the survey should be authorized by Congress. Naturally, it was accepted on the spot, and Hague returned to Boston to find his friend Emmons and acquaint him with his good fortune. Soon afterward he introduced Emmons to King, and this led to the engagement of Emmons as another assistant, and was the commencement of that geological triumvirate which accomplished so much for American geology through what was known as the Geological Exploration of the Fortieth Parallel.

On the 1st of May, 1867, Hague and Emmons, with several other members of the scientific party, sailed from New York for San Francisco by way of Panama, a three-weeks' trip, but much less difficult than the journey across the continent at that time, before the railroad to the Pacific coast was completed, when through travel was by Wells, Fargo and Company's stage-coach. After spending a few days in San Francisco, camp was established in the outskirts of Sacramento, where final preparations for field-work were completed. The party consisted of geologists, topographers, an ornithologist, botanist, and a skilled photographer, besides packers and cooks, for there were to be three parties in the field—one under Hague, another under Emmons—exploring separate areas, while the third was under King, who kept in touch with the work of the two assistant geologists, besides undertaking special researches by himself. Since the geological and topographical surveys were carried on at the same time in each district, there were no maps on which to plot the areal geology until the year after the work was done in the field. Moreover, the scale of the maps was 4 miles to one inch, and the geological work was naturally a reconnaissance.

The country explored was a wilderness, inhabited sparsely by Indians, and to a large extent desert. So it was thought advisable by the War Department to provide an escort of 25 cavalrymen, and occasionally a soldier accompanied the geologist into the mountains. The area to be surveyed was a belt of country 100 miles wide, extending from the California State line to the Great Plains of Wyoming and Colorado east of the Rocky Mountains, and embracing the line of the first transcontinental railroad, afterward known as the Union and the Central Pacific railroads. The work of the survey began at the western edge of the great sage-brush desert in the neighborhood of Pyramid and Winnemucca lakes, and extended through Nevada and Utah and parts of Idaho across the Rocky Mountains, although in the published report the region is described from east westward.

The field season of 1867 was spent in the Humboldt country, in western Nevada; that of 1868 in the remainder of the Great Basin as far as the western edge of the Salt Lake desert. The third season, in 1869, was devoted to the mountains and valleys of the Salt Lake region and the Wasatch Mountains east of it. During the three following seasons the exploration embraced the Mesozoic and Tertiary areas of Utah and Wyoming, the Laramie plains, the northern extension of the Front Range, and the eastern slopes of the mountains. In addition to the survey of the belt of the Fortieth Parallel, Hague explored Mount Hood, while King investigated Mount Shasta and Emmons Mount Rainier, each collecting the volcanic rocks and studying the glacial phenomena.

The geologists spent the winter of 1867-68 in Virginia City, Nevada, studying the Comstock Lode and the geology of the country immediately south of the Fortieth Parallel belt in this vicinity. In volume iii of the published report, entitled "Mining Industry," Hague contributed a chapter on the "Chemistry of the Washoe Process," which included a description of the mineral character of the ore, the chemical action of mercury and other reagents, and pan experiments, which were conducted at the Sheffield Laboratory of Yale College, with the assistance of Mr. Ellsworth Daggett. Hague also wrote a chapter describing the geology of the white-pine district. Subsequent winters were spent in San Francisco, Washington, and New Haven. After the completion of field-work, in 1872, the offices of the Survey were located in New York City, where the report and accompanying atlases were prepared. The collection of rock specimens was deposited in the American Museum of Natural History for safekeeping.

In 1874 Emmons was sent to Europe to study the methods of European geological surveys and to obtain the best and latest geological literature. He was instructed to confer with Professor Zirkel in Leipzig, who had just published his book on the microscopical characters of minerals and rocks,[1] and "to induce him, if possible, to visit America and study in the presence of the collectors their collection of rock specimens, for at that time no American geologist had any practical knowledge of this new branch of geology. From this visit resulted Zirkel's volume on microscopical petrography, which marked the opening of a new era in geological study in the United States." [2]

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[1] Die Mikroskopische Beschaffenheit der Mineralien und Gesteine, von Ferdinand Zirkel, Leipzig, 1873.

It is interesting to note the phases of petrography through which the work of the Geological Exploration of the Fortieth Parallel passed, since this was the first of the larger surveys in this country that took a deep interest in the petrography of eruptive rocks. It began with King's interest in the lavas of the volcanoes of the Pacific coast and in the igneous rocks of the Sierra Nevada. This took definite form through his association with Baron von Richthofen during his visit to the Pacific coast, where he studied the Tertiary volcanic lavas and, observing their strong resemblance to those of Austro-Hungary, wrote his paper on a "Natural System of Volcanic Rocks," which was published in San Francisco in 1868. No doubt this gave King his definite conceptions of rock varieties and their order of eruption, which represented the most advanced views of pre-microscopical petrography and placed King in advance of his assistants of the von Cotta School. Under these influences the volcanic rocks of the region surveyed were studied and classified.

After the collections had been made and brought to New York, Zirkel, the young creator of microscopical petrography, was invited to study the specimens in the presence of the collectors, and we have been told he was much influenced by the eloquent and forceful exposition of King and his associates regarding the nature and occurrence of the rocks. We are led to believe that Zirkel's judgment was warped to some extent in determining the composition of some of the specimens, in particular what were at one time called propylites and trachytes. This opinion would seem to be justified by Zirkel's own statement in his letter transmitting the report to Clarence King. In it he wrote:

> "You well remember that happy time in New York when for many weeks we made together the preliminary examination of that vast col-

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[2] Emmons, S. F. Clarence King, Amer. Journ. Sci., 4th ser., vol. 13, 1902, p. 229.

lection of rocks. . . . You then enabled me to become acquainted with the geological distribution, relative age, and reciprocal connections of the rocks. . . . You know that when we examined the collection macroscopically I entirely agreed with the determination and nomenclature you and your able colleagues had already arrived at in the field. There were only some doubtful occurrences, whose true nature could not at that time be decidedly cleared up. Now, after having carefully studied more than twenty-five hundred thin sections under the microscope, I have only to testify again that your original designations should almost never be altered or corrected."[3]

The report written by Zirkel in English was edited by King and published as volume vi in 1876. Upon its receipt by the geologists of the Survey, appropriate notes regarding the microscopical characters of particular rocks were inserted in the reports of Hague and Emmons in volume ii, which was published the following year. In this manner were blended the best of pre-microscopical petrography with the earliest products of microscopical research.

The results of Hague's geological work in connection with the Exploration of the Fortieth Parallel are published with those of Emmons in volume ii, "Descriptive Geology," each describing those parts of the region specially studied by himself, in some instances with the aid of the other's field-notes or with those of Clarence King. Hague's comment on the volume may be quoted from his memoir of Emmons, prepared for the National Academy of Sciences (p. 321):

"It is a description of the country, treated geographically, beginning on the Great Plains and progressing westward across the widest part of the northern Cordillera. An endeavor is made to give the structural details and salient geological features lying between the meridian 104 degrees west and the meridian 120 degrees west, the latter being the eastern boundary of the State of California. The volume of atlas maps upon which the early geology was laid down, including the accompanying geological cross-sections, bears the imprint of 1876. . . . Nearly all the great divisions of geological time are represented on the atlas sheets, and in volume ii are described with more or less detail. In this volume the term Laramie formation is used in geological literature for the first time. The necessity for a formation name for a great series of beds covering many hundred square miles in area was

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[3] Zirkel, F. Microscopical Petrography. U. S. Geol. Expl. of the 40th Par., vol. vi, Washington, 1876, p. xv.

> readily recognized. The name was suggested by one of the authors of this volume and warmly endorsed by Mr. King, provided it would be acceptable to Dr. Hayden, who had, of course, observed the formation at a number of localities in the Rocky Mountains. Dr. Hayden cordially agreed to the adoption of the term Laramie. During the last thirty years probably no geological horizon has been more discussed from many points of view, with all the accumulated evidence brought to bear upon the study of this series of beds."

Mr. Hague is the geologist who first suggested the use of the term Laramie.

In 1877 Hague became government geologist of Guatemala, having been recommended by the Secretary of the Smithsonian Institution through the Department of State. He spent a year in that country studying its mines and volcanic districts, and upon completion of his survey was obliged to take his pay in silver, an inconvenient burden which he was glad to deposit safely in a San Francisco bank after a voyage up the Pacific coast. The following year he went to China, at the instance of Li Hung Chang, to study the gold, silver, and lead mines of North China for the Chinese Government. Owing to excessive conservatism on the part of some of the higher officials and to a conflict of authority, he was not permitted to accomplish much of economic value. However, he enjoyed excellent opportunities for visiting remote parts of the country under military escort and in native costume. Later he made a tour of his own, in European dress, and enjoyed some novel experiences. He left no record of his researches or observations during these years of service.

In the spring of 1879 the United States Geological Survey was established by act of Congress and Clarence King was appointed its Director. The first field parties were organized and began work the ensuing summer, and Mr. Hague was appointed a geologist, to enter upon his duties when he returned from China. He came back by way of London in March, 1880, and it was in London that the writer of this memoir met him by appointment on the way home from Heidelberg, where he had been studying with Rosenbusch, King having promised a position as assistant to Hague when Hague should take up his duties on the Geological Survey. The meeting took place most informally, in Hague's lodgings, while he was finishing his morning toilet, and was followed by visits to the Museum of Practical Geology, in Jermyn street, where Sir Archibald Geikie and other members of the Geological Survey of the United Kingdom had their offices. The few days together in London and the voyage home to New York were the beginning of years of intimate association in office and camp life, to which the writer looks back with the happiest recollections.

Upon reaching New York, Hague proceeded to Washington to report in person to King and to take the oath of office, which happened on the 10th of April. The first duties of Hague and his assistant were to rearrange and catalogue the extensive collections of rocks made by the Exploration of the Fortieth Parallel, which had been deposited in cabinets in the American Museum of Natural History, in New York, but had become displaced, with respect to their labels, by the movement of the drawers containing them. This involved the identification of the specimens megascopically by comparison with descriptions in volume ii of the published report, and microscopically by a study of the rock sections described by Zirkel—a study of great value to the young assistant. This occupied a considerable part of the following three years, which, however, were devoted to a number of other lines of work.

The summer and autumn of 1880 were spent by Mr. Hague in the field study of the Eureka district, Nevada. His assistants were Charles D. Walcott, fresh from the Grand Canyon of the Colorado, and J. P. Iddings, fresh from laboratory and lecture rooms. The district, twenty miles square, embraced Paleozoic strata and volcanic lavas, with silver-lead mines and prospects, in the desert region of central Nevada. Almost the first night in camp came near being the last; for Mr. Hague, in trying to drive from his sleeping-tent a foraging mule, was kicked in the head above the temple and severely cut, barely escaping with his life. Fortunately, he recovered rapidly and the field-work proceeded normally.

Reference has been made already to his early acquaintance with Bunsen's two-magma hypothesis and the hold it had upon him in later years. In his report on the Eureka district, published in 1892, he recognizes the fact that all the varieties of volcanic rocks in the district "pass by insensible gradations" from one extreme of composition to the other (p. 290), yet he says they clearly belong to two distinct magmas, a "feldspathic" and a "pyroxenic" (p. 255). He states that he "adopts the views of Bunsen as regards two great groups of lavas, but differs with him as to the origin of the varied transition products of eruption" (p. 273). He thinks they were derived from a common reservoir and says he agrees with King's hypothesis as to the origin of rhyolites and basalts. It is to be noted, however, that Hague included all the varieties of andesites in this grouping, whereas they were not so included in King's hypothesis.

It had been the intention of the Director of the Geological Survey that Hague should establish a branch office in San Francisco and should undertake a detailed study of the volcanoes of the Pacific coast, beginning with Lassen Peak. In fact, Hague had been appointed Geologist in charge of the Division of the Pacific. But a sudden change in King's plans, resulting in his resignation of the Directorship of the Survey in March of the following year, 1881, caused Hague to relinquish the position and return with his assistants to New York, where they established their offices in the American Museum of Natural History. Work on the Fortieth Parallel collection was continued in addition to the preparation of the report on the geology of the Eureka district.

No field-work was undertaken by Hague and his assistant, Iddings, during the two following years, 1881 and 1882; but a microscopical study of the volcanic rocks collected by King, Hague, and Emmons from the Pacific Coast volcanoes, and a further study of the igneous rocks of the Great Basin of Utah and Nevada in the collection of the Fortieth Parallel Survey were made by Iddings, and joint papers on the results were published by Hague and his assistant. In like manner a microscopical study of the collection of rocks used by Dr. George F. Becker in preparing his monograph on the Comstock Lode was made and a joint paper based on the results was published by Hague and Iddings as Bulletin 17 of the U. S. Geological Survey. A joint paper was also prepared on volcanic rocks from Salvador, which had been collected by W. A. Goodyear, a classmate of Hague at Yale.

In 1883 Hague was appointed Geologist in charge of the Survey of the Yellowstone National Park and vicinity, and began field-work in August of that year with a large party of assistants, including three assistant geologists—W. H. Weed, G. M. Wright, and J. P. Iddings—a physicist, William Hallock; a chemist, F. A. Gooch; a professional photographer, W. H. Jackson, and a disbursing clerk, C. D. Davis. The completion of the Northern Pacific Railroad later in the summer attracted general attention to the region and added to the interest taken in the natural phenomena for which the park has become famous. Besides the geological features of the region which were the special object of the Survey, the park was to be converted into a national pleasure resort for persons interested in geysers, hot springs, and natural scenery of a remarkable character; it was to be placed under guard as a huge game preserve, and was subsequently set aside as a forest reserve and a protected reservoir for the headwaters of the two great rivers—the Yellowstone-Missouri and the Snake, or Shoshone. In the prosecution and advancement of these diverse phases of development of the Yellowstone National Park, Hague took an active and prominent part, urging their importance upon the government authorities in Washington and advising as to the proper administration of the laws and regulations whereby the various features of the park could be preserved in the best manner, while its functions as a pleasure resort, game and forest reserve were properly maintained. He was an ardent advocate of the preservation of the striking features of the region in their natural state, for placing hotels and other buildings where they would not mar the attractiveness of the localities to which they were tributary. He was a vigorous opponent of the attempt to introduce a railroad in the national park.

In the study of the region he was especially interested in the geysers and hot springs, but maintained a general oversight of the detailed investigations of his assistants into the geological structure of the region, which consists mostly of igneous rocks, with several mountain ranges of stratified rocks. Portions of the area were investigated in detail by Hague himself. The region surveyed was more than 3,000 square miles in extent and the field-work continued for seven seasons, from 1883 to

1889. The following year Weed and Iddings, under the charge of Hague, explored and mapped the geology of the area north of the Yellowstone National Park, known as the Livingston quadrangle.

The descriptive geology, petrography, paleontology, and paleobotany of the park have been published as part 2 of the Yellowstone Park Monograph, in which the chapter on Huckleberry Mountain and Big Game Ridge was prepared by Hague. He made reports on the progress and results of the work from time to time in the Annual Reports of the Director of the U. S. Geological Survey, besides writing several special papers which appeared as presidential addresses before the Geological Society of America and the Geological Society of Washington—one on the early Tertiary volcanoes of the Absaroka Range and the other on the origin of the thermal waters in the Yellowstone National Park.

In 1897, with T. A. Jaggar, Jr., as an assistant, he studied the geology of the country east of the Yellowstone Park, which had been set aside as a forest reserve and had been annexed to the park forest reserve. He revisited the Yellowstone Park a number of times to continue his observations of the hot springs and geysers. A list of his scientific publications is given at the end of this memoir.

In 1885 Arnold Hague was elected a member of the National Academy of Sciences and served as Home Secretary from 1901 to 1913. He represented the Academy at the Quaternary celebration of the University of Aberdeen in 1906; at the Centenary celebration of the Geological Society of London in 1907; at the one hundredth anniversary of the University of Berlin in 1910, and at the 250th anniversary of the Royal Society of London in 1912. He was appointed a member of the Committee on the Inauguration of a Rational Forest Policy for the Forested Lands of the United States in 1896, and with other members of the committee visited all the forest reservations established prior to 1897, except six that were either well known to the members of the committee or were quite small. In this work he took an active part.

He was a Fellow of the Geological Society of London and of the Geological Society of America, being its President in

1910. He was a member of the American Philosophical Society; a Fellow of the American Association for the Advancement of Science; a member of the Society of Naturalists; the Institute of Mining Engineers; the Washington Academy of Science, and the Geological Society of Washington. He was a Vice-President of the International Geological Congress at Paris in 1900; at Stockholm in 1910, and at Toronto in 1913. In 1901 Mr. Hague received the honorary degree of Sc. D. from Columbia University, and in 1906 the degree of LL. D. from the University of Aberdeen. He was a member of the Century Club and of the University Club, in New York City, and of the Cosmos and Metropolitan clubs, in Washington. In 1893 he was married to Mary Bruce Howe, of New York.

Arnold Hague was at all times and under all conditions a gentleman, whether at home, in the social life of the Capital, or about the camp-fire in the mountains; considerate of the feelings of others; temperate in language and habits; by nature reticent and reserved, he was conservative in his opinions, cautious in his judgment, and deliberate in action. Possessed of normal human instincts, he nevertheless exhibited admirable self-control under what were at times most exasperating circumstances, as when upon one occasion his packer, with the mules and camp outfit, deserted him in the mountains and left him to the chance of meeting one of his other parties or of going without food for several days. Fortunately he encountered one of his assistants the next day, and though he was convinced of the treachery of his packer he retained him in his service until the end of the season as the most judicial procedure, it being very difficult to find a substitute.

Mr. Hague was a man of good taste in music and in art, with a fine appreciation of the beautiful in nature, whether the grandeur of mountains, the colors of a sunset, or the somber tones of an autumn meadow. He enjoyed the brilliant tints of the Grand Canyon of the Yellowstone and was particularly fond of the neutral tones and clear atmosphere of desert scenery, and though undemonstrative by temperament he occasionally expressed his enjoyment of beautiful scenery and his pleasure in sharing it with others in a most effective manner. The writer recalls with emotion the interest Arnold Hague took in conducting his young assistant, with eyes shut, to the brink of the Yellowstone Falls, so that he might have the pleasure of a sudden view of the many-colored canyon beyond. Although Hague was greatly interested in the preservation of wild animals within the park, he was no sportsman, and said upon one occasion that he had never killed any game or fish in his life. He was not averse, however, to his assistants keeping the camp table well supplied.

As a geologist and explorer, Hague took a lively interest in discovery, whether a bit of geological structure or the lay of new or little-known country. He delighted to follow an elk trail through a difficult region as well as to unravel a complex piece of stratigraphy, but when he had solved the riddle his interest in it ceased, as he himself has said. He cared little to convey his discoveries to others, and in the matter of opinions or theories he seemed to care less as to what others thought; so that he made little or no effort to influence them, and in consequence was indifferent as to publishing the results of his researches. Moreover, he had high standards both with regard to the character of his work and the mode of its expression in print, and this, in conjunction with his deliberate habits of thought and action, may account for the length of time required for him to bring his reports to what he considered a proper finish.

As his geological assistant through twelve years of field and office work, the writer can testify to the kindly interest and cordial coöperation of Arnold Hague in the work of the beginner, and the writer wishes to take this opportunity to express his gratitude for valuable advice upon critical occasions, and for most liberal treatment in the matter of individual research and independent publication of material investigated under the charge of his chief while in the Yellowstone National Park and elsewhere.

The last years of Dr. Hague's life were spent quietly in Washington and in Newport, R. I., his health and strength declining gradually. At a winter meeting of the Geological Society of America in Albany, December, 1916, on a stormy night, when the pavements were covered with ice, he fell and struck his head, losing consciousness for some time. Although he appeared to have recovered from this accident, his death came suddenly the following May, on the fourteenth, in the 77th year of his age. He was laid to rest in the Albany Rural Cemetery, with others of his family, and near by are the graves not only of his brother James, but of James Hall, Ebenezer Emmons, R. P. Whitfield, Charles S. Prosser, and other men of science.

The spirit of Arnold Hague seems to have been in accord with the tranquillity of a Chinese proverb he was fond of quoting when in the mountains:

> "He who dwells 'midst the turmoil of cities and towns
> Knows not the quiet of rivers and lakes."

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James D. Dana

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BIOGRAPHICAL MEMOIRS
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BIOGRAPHICAL MEMOIR

OF

JAMES DWIGHT DANA

1813-1895

BY

LOUIS V. PIRSSON

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INTRODUCTION

If it appears strange that over twenty years should have elapsed since the death of the noted geologist, James Dwight Dana, before a biographical memoir of his life and work should be presented to the members of this Academy, this has been due to a variety of circumstances, which need not be dwelt upon here. If we have on the one hand the feeling that this should have been done before, on the other there is the advantage that from the time that has passed we are enabled to enlarge our perspective and to see in a clearer light the character of the man and the service which he rendered to American science. During this period, also, a life of Dana and various biographical notices, together with estimates of him as a teacher and as a scientist, have appeared, and this material has been freely used by the writer, upon whom has fallen the privilege of presenting a memoir to the Academy of one of its founders and most distinguished members.*

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* The more important American biographical notices which have come to the attention of the writer are the following:

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James Dwight Dana, by C. E. Beecher, Amer. Geologist, vol XVII, 1896, pp. 1-16.

Memoir of James Dwight Dana, by Joseph Le Conte, Bull. Geol. Soc. Amer., vol. 7, 1896, pp. 461-479.

James Dwight Dana, by J. W. Powell, Science, new ser., vol. III, 1896, pp. 181-185.

A slender, erect figure of medium height; a well-shaped head, crowned with a mass of white hair; a thin, sensitive face with finely carved features, clean shaven, with a bronzed complexion; keen blue eyes and a kindly smile, touched with a trace of humor—such was the appearance of Professor Dana in the fall of 1881, as it impressed itself upon the memory of the writer, who, with other students, met him on a Saturday afternoon for a geological excursion in the environs of New Haven. He was then 68 years old, and still in the very crown of his active life. His alertness, vivacity, quickness of movement, and the general impression of physical energy and vigor which characterized him gave no hint of the many years during which he had struggled against disability. The effect he produced was immediate, and one could not meet him without recognizing at once that he was an extraordinary man, of superior intellect, capacity, and knowledge. The memory of Dana and that excursion as he conducted it is one of the most clearly cut impressions of the student days of the writer.

The last recollection is equally clear. Shortly before his death he brought to the writer's laboratory in Peabody Museum a fragment of rock from a ledge barely exposed in the lagoon of Clipperton Atoll which had been sent him by a naval officer. He believed it to be of volcanic nature, but desired an examination of it according to the latest petrographic methods. It proved to be a fragment of altered trachyte, and thus confirmed him in the view that it represented the final remnant left exposed of a subsiding volcanic island. It was, therefore. to him, almost at the very end of his life, another proof of the correctness of the theory that the Pacific atolls have been formed by the subsidence of oceanic islands—a matter which will be considered more in detail later. He was as full of keen

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Life of James Dwight Dana, by Daniel C. Gilman, 8°, pp. 409, 1899.

Dana the Man, by Wm. North Rice; Dana the Teacher, by E. O. Hovey; Dana the Geologist, by G. P. Merrill; Dana the Zoölogist, by John M. Clarke; addresses at the Dana Centenary of the Geological Society of America, Bull., vol. 24, 1913, pp. 55-69.

The Geology of James Dwight Dana, by Wm. North Rice, in Problems of American Geology, pp. 1-42, a series of lectures delivered at Yale University on the Silliman Foundation, December, 1913, commemorative of J. D. Dana, 8°, pp. 505, New Haven, 1915.

interest over this discovery as he might have been forty years earlier; one could see no abatement of this interest in his work to the very end of his life.

The writer offers these first and last recollections of Professor Dana because they may recall to those yet living who knew him, and who may chance to read this memoir, a similar vivid impression of his striking personality; to those who never knew him it would be difficult to convey in mere words the effect which he made upon the men of his generation. The writer cannot speak of this from any intimate personal knowledge of Professor Dana; when after student days his work in the university began, the latter lived a very retired life, and though busily engaged in work, was not often seen by the younger men, though always helpful and glad to see those who had occasion to consult him upon any problem, and he must, therefore, rely upon the testimony of others. For the purposes of this memoir the life of Dana must be considered from two standpoints: first, the account of his life; and, second, the consideration of his scientific work; one cannot, of course, treat of one without to some extent involving the other. It is natural to begin with his history.

EARLY LIFE

James Dwight Dana was born in Utica, N. Y., on the 12th of February, 1813. He was the eldest of a family of ten children. His father, James Dana, was a native of Massachusetts, a direct descendant of Richard Dana, the original immigrant and progenitor of the Dana family in New England. While the immediate derivation seems pretty clearly to be English, the ultimate origin of this stock is held by many to be Italian, partly on account of the nature of the name and partly because a family of Danas has long been existent in Italy, distinguished in intellectual fields and especially in scientific professions.

James Dana married Harriet Dwight, a daughter of Seth Dwight, of Williamsburg, Mass., and moved to Utica, N. Y., where he died, in 1860, at the age of 80. He was a successful man of business, engaged in mercantile pursuits.

Utica, at the time when the subject of this memoir was born, was a small, active town, which was passing beyond the frontier stage and growing in size and importance. The history of the growth and development of the smaller American inland settlements from villages to towns and from towns to cities has been so often repeated that it is familiar to all and we may thus easily picture the conditions under which Dana grew to manhood. It is perhaps worth while to note how many famous Americans have developed under similar circumstances, and this is, perhaps, not difficult to understand when we reflect that these places have been built up successively by the most hardy, energetic, and industrious of our population. At such periods of development there has been nothing of the influence of inherited wealth on the one hand or of extreme poverty on the other. Achievement in some form or other is the result expected by the community in proportion as the opportunities are many. Having passed the frontier stage, the advantages of education in its simple forms are usually good and becoming better, and there is general insistence that they should be employed. When to this we add that Dana was reared in a home characterized by religious feeling, thrift, and common sense, in which, as he himself has said of his parents, "honesty, virtue, and industry seem almost to be our natural inheritance," it can be seen that the environment in his early years was a most favorable one, and we can understand why he himself was distinguished by those traits which he mentions.

It is reported of Dana that as a boy he was fond of collecting and bringing home natural objects. It may be that this shows the dawning of his instinct toward science; but we must not make too much of this, for it is a trait common to most boys and may well be due to the natural impulse toward acquisition. However this may be, we know that he came first under scientific instruction when, at the age of fourteen, he began to attend the Utica High School, then recently founded by Charles Bartlett, a graduate of Union College, who had studied the character of a number of educational institutions and had the breadth of view and foresight at that day to arrange for a teacher of natural sciences.

This position was first occupied for three years by Fay Edgerton, a graduate of the Rensselaer Polytechnic Institute, who held classes in chemistry, mineralogy, botany, and geology.

There is testimony that he was an enthusiastic and inspiring teacher. Moreover, he had, happily, the all too rare custom of taking his students afield in pursuit of their nature studies. He made long collecting trips with them to particular localities for rocks and minerals. This, which would at once give dignity and standing to the pursuit of his natural instinct, could not fail to have a great influence upon a boy of Dana's tastes. It was here that he received his direct impulse toward science and his first training in the field in which he was to achieve success, as he himself recognized in after years.

Edgerton was succeeded in 1829 by Asa Gray, afterwards the famous botanist and professor at Harvard University, as teacher of natural sciences, and thus there began an acquaintance between him and Dana which ripened into an enduring friendship. Although this friendship was destined later to have a strong influence upon Dana's career, there is no evidence that during the year they were associated in the Bartlett Academy, before Dana went to college, he came directly under Gray's instruction.

In 1830 Dana entered the sophomore class in Yale College and took his degree of Bachelor of Arts in 1833. He was led to choose Yale, according to his statement, by the wide reputation as a teacher of science enjoyed at that time by the elder Benjamin Silliman. We must not conclude from this, however, that Dana had at this time any clear idea of embracing science as a profession, as we shall see later. The opportunities at that time for a scientific career were scanty, and most American naturalists were impelled into one rather by natural instincts and force of circumstances than by deliberate choice, and very commonly passed into one by way of training for the medical profession.

Although the curriculum of the American college was much simpler and less exacting then than now, the fact that Dana was able to enter the sophomore class at the age of 17 and graduate with a good standing in his class is a testimony to his ability and industry as a student. At that time the classics were the backbone of the college course, and the circumstances that Dana had had a rather weak preparation in ancient languages and entered his class a year late are the probable reasons why he did not attain more marked distinction as a general scholar. He was, however, noted for his excellence in mathematics, for which, as we shall see, he had a predilection, and he devoted much time to science, especially to mineralogy and botany.

In his senior year in college we find Dana beginning to concern himself regarding his future career, and in a state of uncertainty which was not resolved until some years later. His love of natural science impelled him in a direction in which he saw no opening, and his father, a practical business man, with a large family dependent upon him, had no belief in the possibility of a successful and independent career in science. In those days an educated man perceived business, the ministry, law, medicine, and teaching open to him as fields of work. For business, law, and medicine Dana, in his letters home, which have been preserved, professed a strong disinclination; of the ministry there seems never to have been any question; and since from the time of his leaving college he must support himself, and did so, he naturally gravitated toward teaching, at which he had begun to earn his living when circumstances opened to him a great opportunity; whereupon he relinquished it until later, when he again assumed it as his vocation.

During his senior year Dana, backed by his friends, solicited from the Government the post of schoolmaster in the Navy. At that time the naval school at Annapolis (1845) had not been founded and it was the custom to furnish the naval vessels carrying midshipmen with teachers who should give suitable instruction to the future officers. Dana obtained the position of instructor in mathematics, was assigned to the *Delaware,* and, in August, 1833, sailed on a cruise to the Mediterranean. The voyage lasted nearly 16 months, and towards the close of 1834 he returned in the frigate *United States,* to which ship he had been transferred at Port Mahon. He visited Minorca and cities on the coast of France and Italy, made an ascent of Vesuvius, passed around Italy through the Straits of Messina, touched at some of the Greek islands, saw Athens, and spent some time at Smyrna.

It can be well imagined that a trip of this nature was not only a source of pleasure, but of great educational value to a young man of Dana's character. He took full advantage of his opportunities and made a number of scientific notes and observations, including some on the geology of Minorca and in the vicinity of Smyrna. A letter of his, descriptive of the condition of Vesuvius as he saw the volcano in July, 1834, to Professor Silliman was published in the *American Journal of Science* and was his first scientific paper. He had leisure time on shipboard which he improved in reading and study. As an evidence of his industry and earnestness of purpose, we learn that he devoted many spare hours to working out problems in mathematical crystallography, in which he used measurements given by Phillips in his mineralogy, and in devising a new system of symbols for crystal planes. To most, and certainly to the great majority of those of us who have performed it, the calculation of crystal constants, however necessary and useful, is a very dry task, and it speaks volumes for Dana's caliber, that, as a youth of 21, amid the bustle of life aboard a naval vessel, he had the tenacity to pursue his favorite study of mineralogy in this way—the only one possible to him on a ship.

EARLY YEARS IN NEW HAVEN

After his return in December, 1834, his time for the next year or so was passed partly in New Haven and partly at his home in Utica. It was a period of anxious uncertainty to him, for as yet he saw no definite opening for a career which he wished to accept. He employed it usefully, however, in continuing his studies in chemistry and mineralogy. We find that he prepared several papers on the latter subject which were published; one of these, on the system of crystal symbols, thought out on his voyage. He also constructed a set of glass models of crystals for instructional purposes. He wrote an article on chemical nomenclature which he sent to Berzelius, the celebrated Swedish chemist, who replied with some kindly criticisms of certain features. It is of interest to note these early papers of Dana, because one sees from them that the orderly presentation, the organization of scientific facts and ideas into systematic form, which was so distinguishing a trait of his intellect, appeared at the very beginning of his career.

He also wrote part of a treatise on crystallography, intending it, as he said, for his own use, but in fact it became the beginning of his great work on mineralogy.

In 1836 Dana obtained the post of assistant to Professor Silliman, a place which had been previously held by the younger Silliman, Charles U. Shepard, Oliver P. Hubbard, and others, who afterwards pursued careers in science. He was pleased at the appointment, for the duties of the position, according to his statement, demanded only about three hours in the day and the remainder of his time he was free to devote to his studies and investigations. He now remained in New Haven for two years, during the first of which he acted as Silliman's assistant, and, probably incited in part by his friends, he continued his treatise on crystallography, added to it one on mineralogy, and thus prepared his first notable contribution to the literature of science, the *System of Mineralogy and Crystallography*. It is by this book (and its subsequent editions) that Dana's name is probably as well known as by any other of his works. We shall have occasion to consider it more in detail in another place, but it may be mentioned here that the manuscript was delivered to the printer in December, 1836, and the book appeared in May, 1837. For a young man not yet 24 years old to prepare the manuscript of a volume of 580 pages in an abstruse field, requiring constant verification of references and numerical constants, in a relatively short time is certainly a marked feat of executive industry. When it is added that the work is no mere compilation, but shows original philosophic conception in its treatment of various subjects, is without any signs of youth or immaturity, and was at once accorded a valued place in science in America and Europe, the work becomes still more remarkable. We must conclude that the material was already stored, in well thought out form, in Dana's mind, and needed for the most part only expression on the paper before him.

This important work at once gave Dana a well-merited standing among scientific men, although his acquirements had been already recognized by his friends and had led to a great opportunity for scientific research which now opened before him.

WILKES' EXPLORING EXPEDITION

About the beginning of the second quarter of the last century there began an agitation for the Government to send an exploring expedition into the Pacific, especially its southern portion. Other navies had already done this to the renown and credit of their governments in the geographical and other discoveries which they had made. Immense areas, however, still remained unexplored and it was felt that the United States, for its own sake in several ways, should join in this work. This movement was started by John N. Reynolds, of Ohio—a man of whom we know little, save that he was intensely interested in geographical exploration and anxious to promote it. He did not succeed at first in interesting the Government and on his own account made a voyage to the Pacific, traveled in Chile, and returned to the United States on an American naval vessel. On his return he began his agitation anew, induced various prominent men and societies to aid him, and finally Congress was moved to act and authorize the expedition when it became convinced that the exploration and surveys suggested would be of value to American commerce, and especially to the whaling industry.

The expedition was authorized in 1836, but two years passed before the necessary preliminaries could be settled and its organization completed. It was recognized from the beginning that the needs of science should be met by the inclusion of a staff of scientific observers. Dana had already, in August, 1836, been approached by Reynolds and offered a post on the staff, but at first declined. Afterward, urged by Asa Gray,* he reconsidered, offered himself as a candidate, and received his commission from the Navy Department in January, 1837. It was to take effect on July 4, 1838, and his salary was to be $2,500 a year and his subsistence while on active duty. One can easily imagine that, especially in those days, a position with such opportunities and pay to an energetic and ambitious young man of 24, dependent on his own exertions, was a most alluring one. It was the turning point in Dana's career.

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* It is an interesting coincidence that Darwin, like Dana, owed his participation in a voyage of world discovery largely to the influence of a botanist, Professor John S. Henslow, of Cambridge University, who urged him to go, and brought him to the notice of Captain Fitzroy.

He was named mineralogist to the expedition; but as the distinction between mineralogy and geology was then not clear as it is today, it was obviously intended by this that he should cover the field of geology, and under similar circumstances at the present time he would have been designated geologist. As we shall see later, he not only covered this subject, but took over a part of the field of zoölogy as well, partly because of the retirement of one of the staff who had undertaken this work. It was intended that Asa Gray should go as botanist and he had accepted the post. No doubt the thought of his companionship had had considerable influence in inducing Dana to reconsider his early refusal, and when Gray, led by the long delay and fine opportunities offered him at Harvard University, resigned his position it must have been a severe disappointment to Dana.

This delay, however, was a fortunate one for him; it enabled him to put his Mineralogy through the press and to prepare for publication several articles he had read before the Yale Natural History Society; to arrange his affairs and to attend meetings of the scientific staff, and generally in such ways as were necessary to qualify himself for the duties of his position.

The expedition finally sailed from Norfolk, Virginia, August 18, 1838, under command of Lieutenant (afterward Rear Admiral) Charles Wilkes, by whose name it was afterward generally known. It consisted of two sloops of war—the *Vincennes* and the *Peacock*—and several smaller vessels attached as supply ships and tenders. In addition to Dana, the scientific corps contained Charles Pickering, naturalist, who afterward attained considerable renown for his writings on the geographical distribution of men, plants, and animals; William D. Brackenridge and William Rich, botanists; Horatio E. Hale, ethnologist, and Joseph P. Couthouy, naturalist. There was added to these Titian R. Peale, of the famous Peale family of artists of Philadelphia, who prepared many of the plants for the scientific reports of the expedition. One should also include the naval officers who acted as geographers and surveyors, and there was an additional personnel of artists and assistants.

It is not our intention here to give any general account of the expedition, for this is a matter of history and well known, but merely to sketch the outline of that part of it which concerns the personal history of Dana.

He was assigned quarters on the *Peacock,* under the command of Lieutenant William L. Hudson, and Peale and Hale were his associates on board.

The squadron sailed first to Funchal, on the island of Madeira, and remained there a month. This gave Dana a good opportunity to study a dissected volcanic island; he had a number of such afterward. After a short visit to St. Iago, in the Cape Verdes, they proceeded to Rio Janeiro. The vessel and its supplies were found to be in poor condition and the fleet remained in Rio six weeks in order to refit. Dana was, as usual, industriously making everywhere good use of his time; on the voyage he was collecting, studying, and figuring oceanic crustacea, of which between the Cape Verdes and Rio he states he found 75 new species. Whenever opportunity afforded he made excursions ashore for geological observations and other studies and for collecting. From Rio the squadron sailed to Cape Horn, where it divided up for exploration. Dana was transferred to the store ship *Relief,* under Lieutenant Long, and it was intended that some weeks should be spent in study and exploration among the islands of the Magellan Straits. The bad weather and violent storms encountered, however, prevented this, and in one terrific gale the vessel, while anchored under Noir Island, for three days was in imminent danger of going ashore, with the certain loss of all on board, as one anchor after another gave way. Dana has left a thrilling account of this harrowing experience in a letter to a New Haven friend. Having lost all her anchors, the vessel could no longer remain in the Straits, and in order to refit sailed for Valparaiso, which was the general rendezvous of the fleet. They arrived there in April, 1839, and remained a number of weeks. Dana improved this opportunity, with the other naturalists, by making excursions in Chile, on which he made several mountain ascents to study the geology and to obtain views of the Andes.

From Valparaiso the expedition went to Callao, in Peru, where further inland excursions were made, and in July it sailed for its essential task of exploration in the South Seas. The following month it arrived in the Low Archipelago, or Tuomata group. A number of islands were visited and the explorers proceeded to Tahiti, where some time was spent and surveys made. The Samoan group was next taken up and surveyed and mapped, the stay lasting until November 10, 1839, when the expedition sailed for Sydney, in New South Wales, where they arrived after three weeks. This portion of the voyage was Dana's introduction to the coral islands. Outside of the geology of volcanic masses as shown by many of the islands and their dissection by weathering, it must have been the coral reefs, with their richness of hitherto unknown and undescribed life, which chiefly occupied his time and attention, and we shall see later the results of these studies.

At Sydney a division of the work took place. The scientists, including Dana, were sent ashore, with orders to rendezvous later in New Zealand, while Wilkes with his vessels departed on his famous voyage in the Antarctic seas, when the great ice-barrier and the lands of the Antarctic continent were discovered. Meanwhile Dana made excursions in southern Australia, studying the country and its geology and collecting fossils, and after a couple of months proceeded in a sailing vessel, in which the corps of scientists found passage, to New Zealand, where they arrived February 24, 1840. While pursuing their researches and awaiting the arrival of Wilkes, they witnessed the acquisition of the islands by the British Government and the treaty-making with the native chiefs. When the vessels arrived from the southern voyage they went first to the Tonga Islands, then to the Fiji group, where they remained three months making surveys. In August, 1840, the squadron sailed for Hawaii, visiting several islands of the Phœnix group en route, and arrived at Honolulu on the 25th of September. Here, among other things, Dana had his great opportunity of studying volcanoes and volcanism in his visits to Mauna Loa, Kilauea, and other points. To confirm observations then made and to witness intervening changes, he revisited this region 47 years later, at the age of 74 years.

From Hawaii the *Peacock*, with Dana on board, returned (December 2, 1840) to Samoa for further work, visited the Ellice group, then the Kingsmill, or Gilbert, Islands, went back to Honolulu, and from there to the mouth of the Columbia River. Attempting here to enter the river, the vessel was wrecked on the bar on the 18th of July, 1841, and after great peril all hands were saved, but their effects and much of the scientific results of their explorations were lost. They were rejoined here by Wilkes, who had been making surveys in Puget Sound; he remained in one vessel to survey the Columbia, while the *Vincennes* was sent to San Francisco. Meanwhile a party, under Lieutenant Emmons of the lost vessel, among whom was Dana, went overland to the same place. They ascended the Willamette, crossed the intervening ranges of the Cascade Mountains, passed by Mount Shasta, and descended the Sacramento River. This trip, an adventurous one for those days, must have offered the hardy explorers a great contrast with their recent work in the South Sea Islands. Although they had no idea of the remarkable activities that would begin less than ten years later, in the gold era of California, in those remote regions of Sacramento, it is interesting to observe that the geology of the country impressed Dana as being favorable for the finding of gold, and he so stated it in his report of the expedition.

The squadron reassembled at San Francisco, which at this time was a small village; a vessel, the *Oregon,* was bought to replace the lost *Peacock,* and at the end of October, 1841, it was ready to start on its homeward journey. By the way of Honolulu, where supplies were laid in, the expedition sailed toward the coast of Asia. Wilkes on the *Vincennes*, with Dana on board, proceeded to Manila; the other vessels went through the China Sea to Singapore. In the Philippines Dana had opportunity to make a short geological excursion. From here the vessel went to the Sulu Sea, where important surveys were made; then on to Singapore, whence the reunited squadron sailed for home by way of the Cape of Good Hope and the Island of St. Helena. The *Vincennes* reached New York Bay on June 10, 1842, and this important chapter in Dana's life was ended.

It must be clear to every one that in taking part in this expedition, especially at the time when it was made, Dana enjoyed an opportunity which comes to the lot of few naturalists. This was recognized by Dana himself, as his letters show. It is one thing, however, to have opportunities and another thing to take advantage of them; that Dana fully employed his will appear in the sequel. It should, however, be stated in truth that much of his work on this voyage, as well as that of other members of the scientific staff, was done under disadvantageous circumstances. The importance of scientific work was not at that time accorded the recognition which it has since received, and the naval officers of the expedition, with little or no sympathy for or appreciation of any scientific work outside of the domains of geography, hydrography, and meteorology, in which they were interested, offered no coöperation, and not infrequently placed unnecessary hindrances in the way of the scientists to prevent them from carrying out their duties. Honor to whom honor is due. At the present time, in the minds of educated people, outside of those engaged in cartography, only two matters of interest which now seem of importance regarding this expedition survive—Wilkes' discoveries in the Antarctic seas and the results of Dana's scientific work. Let us be thankful that a different spirit regarding scientific men and their labor prevails at the present time.

THE REPORTS TO THE GOVERNMENT

On his return to the United States, in 1842, Dana established himself in Washington for the preparation and writing of his reports, and this labor occupied the larger part of his time for the next 13 years. He had been, as stated, appointed in the field of geology, but since during the voyage so much of the time was passed at sea and the opportunities for geological research were of necessity limited, he had worked largely in the domain of zoölogy, especially as the retirement of J. P. Couthouy, the naturalist, had caused this subject to devolve upon him, as previously mentioned. This is shown in a letter of his to Asa Gray, written in June, 1840, reviewing the results of his work on the trip to that date:

"In the geological line I shall be able to show you some long manuscripts; their other qualities I leave for you to judge of at a future day. Accompanying the manuscripts there are about one hundred sketches of mountains, craters, basaltic causeways and caverns, faults and dikes, etc. My fossils, which include a large collection of the coral vegetation of Australia, were packed up without examination. Since arriving among the Fijis, I have taken hold of the corals and figured 175 species, with the animals of most of them. Among crustacea I have made collections and drawings, when geology was not requiring my time. My drawings are mostly confined to the smaller crustacèa, and in all probability very few will turn out described species. I count up now 400 species, figured or painted, of which nearly 150 belong to the old class *Entomostraca*."

After discussion of the subject, which lasted some time, it was finally decided by the authorities at Washington that Dana should assume the reports on corals and crustacea in addition to that on geology. He was compelled, however, in order to make the work on the corals complete, to add the coral-making animals and the allied forms, the sea-anemones and hydroids. This report on the Zoöphytes (Anthozoa) was the one first published; it appeared in 1846 and was a quarto volume of 741 pages, with a folio atlas of 61 plates. The colored drawings of the corals were made by Dana himself, as indicated in the previous paragraph. We shall refer to this volume later.

Meanwhile, before this work appeared, he had published several short papers and also a new and enlarged edition of his *System of Mineralogy*.

In 1844 Dana returned to New Haven to live. He did not like Washington, where he was subjected to petty restrictions on the employment of his time, as if he were a clerk in an office. Washington at that time was a very different place from what it has since become—the scientific center of the country. There were no scientific institutions at that time, no museums, collections, laboratories, or libraries. As he wrote a friend: "It is perfectly absurd that I should be able to prepare my reports in a city where there are no books!" It was natural, then, that Dana, dissatisfied with the lack of facilities at Washington, should turn to New Haven, where they existed, where he had many friends and felt at home, and where, moreover, his fiancée, Miss Henrietta Silliman, daughter of his former instructor, the elder Benjamin Silliman, lived. They were married on June 5, 1844, and New Haven then became his permanent home.

During the next ten years, until 1854, when the last of the reports on the Wilkes Exploring Expedition appeared, Dana was actively engaged in research and the finishing of these reports and in writing. A great number of shorter articles appeared from his pen, and a glance at his bibliography, appended to this memoir, shows that they were upon the most varied subjects: articles upon minerals, papers of a zoölogical nature, chiefly upon corals and crustacea, not alone descriptive, but bringing out broad principles of distribution and classification; many papers on geological subjects, also of a broad and general nature, such as the origin of continents, on coral islands, etc., and others on fossils. These were published mostly in the *American Journal of Science,* of which he became an associate editor in 1846. These shorter papers are to be regarded, however, as incidental to his chief works. In 1848 he brought out a *Manual of Mineralogy* (12°, 430 pp.), a shorter work than the *System,* intended for more popular use and for teaching purposes. The third edition of the *System of Mineralogy* appeared in 1850, a volume of 711 pages, and the fourth in 1854, 854 pages, in two volumes.

His report on the Zoöphytes of the Wilkes Expedition, a quarto volume of 741 pages and folio atlas of 61 plates, appeared in 1846, and the report on the Geology of the Expedition was published in 1849, a quarto volume of 756 pages, with folio atlas of 21 plates. The last report on the Crustacea appeared (1852-1854) in two volumes of 1,620 pages, collectively, with folio atlas of 96 plates. In these works, as previously indicated, the plates were largely prepared by Dana himself. In 1853 he published a short, popular treatise on "Coral Reefs and Islands."

These details are mentioned in order that one may judge during this period of Dana's activities and industry; it was probably the most productive period of his life. He received a modest stipend from the Government, and this with some private means permitted him to live quietly and devote himself to scientific work. In that day there was little opportunity for one to assume a career in pure science unless his own fortune allowed him to do so. Dana, as he himself has stated, was fortunate in his opportunity, and, possessed at that period of good health and abounding energy, he was enabled to accomplish an enormous amount of work of the highest excellence, as indicated by what has been written above.

Before dismissing the subject of the Expedition reports, a word further in respect to them may be added here. I believe that those of us who have done scientific work for the Government and have furnished reports upon it have, without suspecting it, benefited in considerable measure by the education regarding such matters which Dana and his scientific colleagues of the Wilkes Expedition were compelled, as well as they could, to give to officials of executive departments of the Government. It goes, of course, without saying that where there is unbalanced enthusiasm and lack of judgment on one side and a too narrow exercise of red tape and interpretation of official precedent on the other, there is likely to be trouble; but we are not today hampered by constant directions as to how reports should be written, what should be included and what left out. Also, incredible as it may seem in this day of liberal publication and desire to diffuse knowledge as widely as possible, it was then felt in Congress that the value of the reports would be much enhanced by a very restricted publication of them. Thus of the report on corals 100 copies were to be printed for the Government and 75 for the publishing firm to sell, and strong objection was made to Dana's printing, at his own expense, 25 copies more for his own use! The idea was that the few great libraries and crowned heads, to whom official copies were to be sent by the Government, would value them much more if they knew they were receiving a *rara avis*. It is for this reason that these reports are so hard to obtain and are so difficult of access, and it would be a very grateful thing if a new edition in compact form, with photographic reproduction of the plates, of these classics in the literature of American science could be published for the benefit of scientific workers.

PROFESSORSHIP IN YALE COLLEGE

The finishing of the Expedition reports may be said to have closed a distinct chapter in Dana's life. Since his means did not permit him to live a life wholly detached for scientific work, it became necessary while writing them to look forward to continuing his career along lines which would give him adequate support. It can hardly be imagined that this matter could have occasioned him any prolonged or deep anxiety. Although Dana was always very modest in his estimate of himself and his work, he had too much good sense not to know that by this time he was one of the best-known naturalists in the country, recognized everywhere in the world as one of the leading men of science, and that there must be institutions which would be only too glad to obtain his services. Harvard University had indeed already made tentatives in this direction. His friends, however, felt that Dana should be retained in New Haven and definitely connected with Yale College, and under the inspiration and assistance of the late Professor E. E. Salisbury, Oriental scholar and philologist, a fund for the endowment of the Silliman professorship of Natural History was established and he was invited to fill the chair.

This was in 1850; but Dana did not assume the duties of the post until February, 1856, when his inaugural lecture was delivered. He was then 43 years old, and from that time until 1890 he stood in close connection with the college and its aims and activities until ill health and advancing years made it necessary for him to retire; he was then, be it noted, in his 77th year! Of his work as a teacher and college officer we shall take occasion to say a word later.

BREAKDOWN IN HEALTH

Dana was now definitely fixed in his career; life stretched before him in lines of work in which he excelled and which he enjoyed. The tasks of his position in the college, editorial work, and the management of the *American Journal of Science*, the preparation of scientific books and papers, and the revision of his works already printed, together with research and fieldwork in his favorite subjects of geology and mineralogy, and the conducting of a considerable correspondence with scientific men at home and abroad—these filled his time and gave scope to his energies.

In the next year or two he produced a number of interesting and important shorter papers and a newly revised edition of his *Manual of Mineralogy;* but the hand of warning was already stretched out, and from incessant labor his health broke down, and in 1859 he was compelled to stop work and give himself a rest to recuperate.

In writing this memoir of Dana perhaps nothing has impressed me more than the enormous amount of work which he accomplished in the 10-year period between 1844 and 1854, when the last of the reports was completed and which I have indicated as the most productive portion of his life. One may see this from the facts so baldly stated in his bibliography. One finds that in this period he completed three quarto reports of 3,117 pages, two smaller books of 574 pages, and to the close of 1854 64 shorter articles aggregating 832 pages. In addition there were three revisions of the *System of Mineralogy,* involving each time much rewriting and inclusion of new matter, with a total of 2,205 pages. Some of the material of the shorter papers was included later in the larger works, but in total there are 6,728 pages of material prepared and seen through the press. Think of the proof-reading alone involved, to which that done for the Journal must be added! This was a tremendous task for one man to perform, and we do not need to look further to understand why Dana broke down from nervous exhaustion in 1859 and never fully recovered his normal health.

He went to Europe for a period of ten months for recuperation, but did not gain greatly from it, and some years afterward broke down again; several interruptions from illness also occurred, and during all the latter part of his life he was compelled to live under a very strict regimen of hours for work and for rest and sleep. He was obliged to give up social intercourse, with its pleasures and excitements, almost entirely and to live a very guarded and secluded life. This was a great deprivation to Dana himself and to his family, as he was naturally of a friendly social disposition and enjoyed meeting his friends and associates. His work at times for long periods had to be confined to one or two hours a day, perhaps to his classroom duties alone. Yet, in spite of these limitations and interruptions, during the thirty-odd remaining years of his life Dana

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accomplished in sum total an enormous amount of work, as may be seen by reference to his bibliography. It was undoubtedly a real loss to American science that through overwork Dana lost his normal health while still a comparatively young man and was unable to take part in executive or public ways during the important years when the growth of science was so rapid and its organization and direction were being determined.

Through the medium of the *American Journal of Science* and his correspondence his influence was wide and constantly felt; but one can easily imagine what a help and stimulus he might have been if he could have played an active part in the organizations in which he was naturally interested, as, for instance, in the meetings and conducting of this Academy. President Gilman in his life of Dana gives letters to him from Agassiz and Darwin, both of whom were victims of ill health caused by overwork, warning him of its evils—warnings which none of the three regarded.

One result of Dana's breakdown was important in a scientific way and should be mentioned. He was compelled to live more or less in the open air and take active exercise. He began to take long walks, and in so doing the geology of the regions which came under his eye attracted him, and he was thus led into active field-work and a lively interest in the geology of southern New England and eastern New York State, upon which in ensuing years he made many researches and published a considerable number of important papers.

MANUAL OF GEOLOGY AND OTHER WORKS

In teaching his classes Dana had felt the lack of a suitable text-book, one especially adapted to the needs of American students, and recognizing that this want must be generally felt, and that such a book would have a broad field of usefulness, as soon as his health would permit him to do so, he commenced to prepare it, and in 1862 published the first edition of his *Manual of Geology*. Of the nature of this work and its successive editions we shall take occasion to speak later, and also of its influence on the development of geology in this country. It is sufficient to say here that it had a great and immediate success, and that it is, perhaps, that one of Dana's works which has had the widest circulation and is the one by which in the popular mind he is best known. A smaller work, adapted to younger and less advanced classes and general reading, under the title of a *Text-book of Geology,* was issued shortly after, in 1864.

He then undertook the revision of the *System of Mineralogy* for a fifth edition, and the work was published in 1868. With each successive edition of this great work the task of revision, owing to the increase of knowledge in this field, had become proportionately greater, and the 14 intervening years since the fourth edition had been very fruitful ones in research. Dana had the aid of the late Professor George J. Brush in preparing part of the work and in proof-reading; but in spite of this the task was very great, especially as he added several improvements which entailed a most laborious search of the literature of the subject. It was the last edition prepared by Dana, the succeeding sixth one being carried out by his son, Edward S. Dana, and he again broke down in health after it was finished and for a time was compelled to suspend all work.

LATER YEARS

Meanwhile and in succeeding years Dana, as his health permitted, was steadily contributing shorter articles to the *American Journal of Science,* which were for the most part in the domain of geology. After his son, Edward S. Dana, began work in mineralogy we find only one more paper directly upon minerals published by him—in 1874. There were a few papers of a paleontological or biological character, and that he never lost his interest in the field of zoölogy is shown by the fact that his last original contribution to the *Journal,* which appeared in 1894, was on the derivation and homologies of some articulates. In the province of geology, however, these shorter papers of Dana, published in the last twenty years of his life, range over nearly the whole field and, touching upon the most varied topics, they indicate the breadth of his reading and interests and how firm a grasp he kept upon the progress of his favorite science in practically all of its development.

In 1880 he brought out a new edition of the *Manual of Geology,* but doing this overtaxed his strength; he was obliged for a time to relinquish class-room work, and in the next succeeding years his activities, beyond his college duties, were mainly confined to the preparation of the shorter geological articles and his field-work in Connecticut and eastern New York.

In 1887 his health seemed in great measure restored; he was much interested at this time in the nature and manifestations of volcanism, and he decided to revisit the Hawaiian Islands and see the changes which had occurred in the crater pit of Kilauea since his former view of it in 1840, when with the Wilkes Expedition. Nothing, perhaps, could illustrate better the unconquerable energy of Dana than that, in the 75th year of his age, he should undertake this long and in some parts difficult and fatiguing journey, where a number of times he made long trips on horseback, camped out at night, and made difficult ascents and descents. He was accompanied by his wife and younger daughter. It was the first long journey he had made since his visit to Europe in 1860—at which time he also revisited Vesuvius—and he withstood the incident fatigue remarkably well.

As the result of his observations in the Hawaiian Islands, Dana learned much, and in the succeeding two or three years he published a series of papers in the *American Journal of Science,* mostly on the history of the changes in the volcanic craters on Mauna Loa and giving his views on volcanic energy. This material, with added matter, and a chapter on the petrography of the Hawaiian lavas by Edward S. Dana, was recast into a work of 400 pages, entitled *Characteristics of Volcanoes,* which appeared in 1890, and at the time a second edition of the *Corals and Coral Islands* was published as a companion volume.

At this period his health again lapsed and he was compelled to relinquish his active college duties. For a time his classes were conducted by the late Professor Charles E. Beecher, until in 1892 the late Professor Henry S. Williams, afterwards of Cornell University, succeeded him in the Silliman professorship.

Dana was now (1892) in his 80th year; he stood like a Nestor in American science—full of years, of dignities, of honors, with the record of a life of wonderful accomplishment behind him; his health and strength were strictly limited. It would seem to most men as if the period of a well-earned repose had arrived. Not so Dana; an inextinguishable fire of energy and enthusiasm was his; he was one of those spirits which must die with the harness on, working to the last.

A number of short papers and a small volume on the local geology of the New Haven region came from his pen. The revision for a fourth edition of his *Manual of Geology* had been in preparation; this was now taken up and brought gradually, with some aid, joyfully given, from some of the younger workers in the science, to completion. It was an octavo volume of 1,057 pages; and when one considers that the work was practically rewritten, the vast amount of material it contains, and the study and familiarity of the literature it indicates, as well as the task of proof-reading, one cannot but be struck with wonder that a man of his age could have completed such an undertaking. It was his last notable achievement and he lived to see the completed volume in his hands.

His work on this book was finished in February, 1895. During the two months following he occupied himself in revising the texts of his elementary works on geology. His mind was as active and keen as ever, and he was still able to take considerable physical exercise. On April 13 he was about his regular occupations, cheerful as usual. In the evening he had a slight attack of trouble with the heart; the following evening, April 14, 1895, it recurred and he passed quickly and peacefully away. It was a most happy ending of a life of remarkable achievement, full of years and honor.

Professor Dana was survived by his wife (died January 3, 1907) and four children, two sons and two daughters, all of whom are still living.

PART II

REVIEW OF DANA'S SCIENTIFIC WORK

In the foregoing pages there has been given an account of the main features of Dana's life and the sequence of the production of his scientific work has been traced. It is now proper and fitting that these achievements should be considered and their importance in the structure of science and their influence in its development be pointed out.

Dana was one of the older school of naturalists; like Darwin, Agassiz, Wallace, and others, he began his career at a time when the domain of the natural sciences, as compared with its condition today, was limited and it was possible for men of their quality of mind to absorb, while still young, the facts and ideas necessary to appreciate its development in several different fields of knowledge, and to pursue research when desired in each of these fields. As time passed, with the volume of knowledge in each line continually increasing, specialization became more and more apparent and necessary; yet these men in great measure were still able to maintain their grasp of the progress in different branches, owing to their breadth of mind and industry in acquiring new facts and ideas as they appeared. Dana was especially distinguished in this way, and one may practically say that to the end of his life he followed the whole group of geological sciences, from mineralogy at one end to paleontology at the other, and from there on into the field of zoölogy. It seems impossible for men to do this today, for as the circle of knowledge ever increases, though the length of arc one can observe may remain the same, the number of degrees continually lessens. Although this in essence must be true, one cannot, however, be dogmatic in such an assertion, for even in this day there appear now and then men who may win distinction by their work in a group of sciences.

It seems safe to say, at least, that there is now no one man who can pronounce authoritatively and fully upon the value and bearing of all of Dana's work in science, and least of all does the writer of this memoir feel himself capable of doing so. We must, therefore, be guided largely by the opinions of others, and, since there has appeared in the years that have intervened after his death a considerable volume of such opinion by those who are qualified to judge, it is now easier to form a just estimate. Also, we have additional evidence from the views of his contemporaries, expressed at one period or another during his lifetime.

Dana's influence upon the development of the lines of science in which he was interested was exerted in three directions, each of which must be considered: by his published works, by his editorship of the *American Journal of Science,* and by his services as a college officer. As the most important of these we shall first examine his original contributions to science, which must naturally be done under the three chief departments of Mineralogy, Geology, and Zoölogy, in which his activities were displayed.

IN MINERALOGY

Through the labors of Dana and those of his son, Edward S. Dana, who has carried forward his work, the family name has become indissolubly connected with this branch of science. The connection is indeed so intimate that it is possible in the future his name will be more popularly known for his services in this field than in any other, though such an estimate would not be a correct judgment of his greatest claim to distinction.

Dana's contributions to mineralogy, as the result of his own researches, are of a high order of merit—they are clean cut, accurate, and discriminating. They are upon the physical side of the science rather than the chemical, except as the latter is considered from theoretical viewpoints, and are largely crystallographic. This was natural, both from the mathematical bent of Dana's mind and the small opportunities for working in the chemical direction which presented themselves in his younger days. It is, perhaps, fortunate that no temptations to research offered themselves in chemical mineralogy, for this is relatively a narrower field, while the nature of his mind qualified him for work and success in a much broader one.

His chief service to mineralogy was not, however, the results of his investigations upon particular minerals, nor his expressed views upon certain phases of the subject, however valuable these may be considered, but in the preparation of his great work, the *System of Mineralogy*. In this some of the most striking qualities of Dana's mind are revealed: his power of coördination and organization into orderly form of facts and ideas, his ability to grasp and retain a vast amount of material, and his unwearied industry that enabled him to bring a great task to quick completion. The feat he performed in writing the first edition has been previously alluded to. It was also not a mere compilation, for it contains new ideas in regard to crystallography and crystallogeny.

At first Dana was committed to a certain form of classification and to a Latin dual synonymy, similar to that employed in the biologic sciences. The growth of knowledge on the chemical side made this increasingly distasteful to him as its disadvantages became more apparent, and in the third edition he threw the whole plan overboard and adopted one, more fully developed in the fourth edition and since almost universally used, which is based largely on chemical principles. In his preface to this edition he makes a characteristic remark, which shows his openness of mind, that while he might seem to be fickle in discarding the Natural History plan after promising to use and support it, it was much worse to persist in error after the latter has been demonstrated.

In the fifth edition the theoretical matter was largely eliminated and the work devoted to the description of species. It was the most extensive examination and compendium of the literature that had then appeared, and one of its most valuable features is a complete study of the historical synonymy of mineral species. The amount of included matter, aided by rigid condensation, is enormous and the work the achievement of a colossal task.

It seems appropriate to add that the sixth edition of this great work was published 24 years later by Edward S. Dana; the included material is here more than one-half as great and an entire recalculation of the crystallographic constants was made, the text being in large part rewritten.

The influence of this work on the progress of the science of mineralogy, especially in this country, it is impossible to adequately estimate. For 80 years it has been the indispensable manual of reference for all workers in the science and in related sciences and arts, as in chemistry, geology, mining, etc. Had Dana accomplished no work other than that which he did in mineralogy, we might yet justly feel that his career had been a notable one. His position in the science is much like that of Linnæus, who has been termed the father of systematic botany. Unlike Linnæus, he was able to change his system of classification to a natural one, and did so, achieving also in his science what de Jussieu and de Candolle did in botany.

Finally we must also recall the very useful text-book, the *Manual of Mineralogy,* which passed through many editions and was for years of service to teachers and students in this science.

IN GEOLOGY

Dana was naturally led into this field of science by the circumstances of his life, as has been shown in the foregoing pages. He was one of the earliest of our geologists with an official position, although, as noted, his title was that of mineralogist in the Wilkes Expedition. His preparation for actual field-work, as we should view it today, was scanty, but it was as good as could be had in that day. In addition to what was known of the subject itself, he had had training in chemistry, mineralogy, and mathematics, solid bases on which to build, and his studies in zoölogy were, of course, the foundation for his work on the historical side. He was not altogether devoid of actual field experience; for in his school and college courses he had had some advantages, and in his first voyage to the Mediterranean he had had opportunities to study volcanic islands and to see Vesuvius.

On a naval expedition, like that in which Dana took part, the occasions when detailed geological studies can be made are, naturally, not many. Long periods of time were passed at sea, other periods were spent surveying islands which presented no material but coral masses and sand; in others, volcanic rocks were present, but the dense growth of vegetation or the presence of hostile savages, or both, forbade observations, except such as could be made along the shores. Sometimes, as in the

Hawaiian Islands, longer excursions were made inland with great profit. His opportunities, however, we must remember, were not wholly confined to the smaller oceanic islands; for trips inland were made in Chile, Australia, New Zealand and in Oregon and California, though there were not many occasions on these for other than general observations on the nature of the country. In spite of these disadvantages, Dana collected a valuable amount of information, as may be seen by reference to his geological report, and the nature of his mind led him to attempt to classify the facts obtained and to endeavor to bring them into harmony with the general principles of geology as then known, and to deduce further generalizations from his studies.

As a result of his experiences on the Wilkes Expedition, Dana was led to take a special interest in the origin of coral islands and in volcanoes and volcanism. His devotion to mineralogy and its applications induced particular consideration of crystalline rocks and metamorphism, and the broader results of these studies are seen in his views of the development of the earth and its features as a whole. There is also to be considered his field-work in New England; but this will be treated later, and meanwhile the topics mentioned above may be discussed.

From his study of the coral islands and reefs in the South Seas, Dana was forced, like Darwin, to believe that the barrier reefs and atolls had been formed around islands, chiefly volcanic, by slow and profound subsidence of the ocean floor. Both observers reached this conclusion independently. Darwin antedated Dana in publication, but as the latter brought forward new facts in proof of the view and strongly supported it, the theory is commonly attributed to them unitedly. In later years the validity of this view as an explanation was attacked by Sir John Murray and Alexander Agassiz, who held that the peculiarities of coral reefs could be explained by conditions of growth of the reefs and that subsidence was not necessary. It may be pointed out that the two views are not exclusive, the one of the other, but that the reefs might be formed on either assumption, or by a combination of them. Rather recently other factors in the problem have been brought forward, such as the changes in ocean levels induced by the storing on the land, and subsequent melting, of glacial ice-caps—a matter which in his day Dana could not have known the extent of or taken into account. It thus appears that the problem is much more complicated than was at first imagined, and it is probable that at the present time no single simple explanation could be advanced which would be universally accepted. Nevertheless, it still remains Dana's merit to have pointed out that the reefs are connected with changes of sea-level and, as so well urged by Professor William M. Davis, to have called attention to the facts of the topography of the islands, which indubitably prove that such changes have taken place. Valuable features of the theory will, therefore, persist, whether the view of profound oceanic subsidence is finally accepted or not.

Volcanism may be said to be that field of geology in which Dana began his work, his first published paper being one on Vesuvius. It was also the field in which he had some of his best opportunities while on the Wilkes Expedition. The interest thus excited early in life remained with him to the end, as shown by his second journey to Hawaii, in the 75th year of his age, and the subsequent issue of his volume on volcanoes. It is also shown by the fact that in the *Manual of Geology*, published in the last year of his life, the space allotted to this topic is much greater, relatively, than is usual in text-books on this science by others. His contributions in this field are of great importance and will remain permanently of value, for they are mainly original observations of facts, and his mind was too clear and sane to hazard, as some have done, a mass of speculations which later knowledge might completely disprove.

When Dana was nearly 60 years old, as his health demanded more exercise and life in the open air, he began his field-work on the highly crystalline rocks of western New England. His previous papers, books, and reviews show he had always had an interest in metamorphic rocks and metamorphism, into which he had been naturally led by his labors in mineralogy. These field studies Dana continued for many years, during which time he investigated and mapped many areas with the most laborious detail. He recognized that if anything of value was to be obtained concerning the geology of the region it could only be done by the most painstaking of field study, and his course in this respect was in sharp contrast to much, perhaps most, of the previous work that had been done here, in which deductive reasoning and pure speculation had been at a maximum, while collection of facts by careful field-work and induction from them had been at a minimum. This was the first serious original work of Dana in what we should now call structural geology, the attempt to unravel the geological history of a particular region by a laborious collection of detailed observations.

One is led here to pause and wonder what would have been the history of American geology if the earlier workers in it could have started their labors in our west, in the region of the Rocky Mountains, for instance, instead of in the area of the northern Atlantic border, in New England, eastern New York and Pennsylvania, and eastern Canada. On the one hand, magnificent exposures; structural geology clearly displayed on a large and evident scale; stratigraphic series laid open to observation; every stage from intrusive to extrusive effects of volcanic energy bared by dissection, and other advantages every geologist will recognize. On the other hand, an enormously complicated series of problems, some of them still today baffling in spite of all our modern instruments and methods, subjected to vast erosion, largely masked by vegetation and heavy deposits of glacial drift. These earlier workers had no good topographical maps, none of our present developed methods of field-work, no help from the microscope, little or no resource in analytical chemistry, nor the innumerable aids which the development of all physical science and mathematics affords us today in testing conclusions. This should always be considered in making a just estimate of the work of Dana and others in this difficult region; the wonder should be, not that what we now consider are mistakes were made or erroneous conclusions were sometimes drawn, but that in spite of so many obstacles so much was accomplished.

The work of Dana in southwestern New England and eastern New York was very valuable; as a result of it a mass of misinformation and misconception was cleared away and the problems clearly brought to view; a great mass of facts was collected and stored away. While some of his conclusions have been changed, others will permanently stand. Thus we must in large degree regard his work as fundamental, as the basis upon which the later structure of the geological history of the region is being built.

Also, we must not omit to mention that the other chief aspects of southern New England geology, its Triassic sandstones and their inclusion of trap masses and the results of the glacial invasion, attracted Dana's attention, and about them, also, he collected stores of data and published many papers embodying his conclusions. In reading his papers on the structure and history of the Triassic area, one cannot help wishing that he might have had the benefit of observing some of our western geology; much that seemed so difficult to him, with his clear mind, would have been so much easier and more comprehensible. His observations on the glacial geology and deposits will always remain a valuable chapter in the history of this phase of American geology.

The most valuable contributions which Dana has made to geologic science were not so much those which add to our knowledge of particular areas, but those broad generalizations which form some of the very bases upon which the science of today is founded. Some of these he set forth while he was still a young geologist, and it seems to the writer that he was naturally led into this line of thought by his observations on coral islands while on Wilkes' Expedition. To a mind which, like Dana's, had power to grasp a mass of details, to perceive the essential among them, and to deduce important principles therefrom, the sequence of thought seems to run irresistibly as follows: the coral islands denote subsidence of the ocean floor; such vast subsidence must condition uprising elsewhere, hence upon the continents; this may have been a continuous process, caused by the earth's contraction from cooling, hence the growth of the continents; such effects would produce lateral thrusts against the continental borders, which result in mountain-making; therefore mountains occur upon the continental borders. It seems as if we could almost see these successive steps and the viewpoints they opened out in

Dana's mind if we simply place before us the titles of the shorter geological papers he published in the years succeeding his return from the voyage, in their successive order:

Areas of subsidence in the Pacific, as indicated by the distribution of coral islands.

The origin of continents.

Geological results of the earth's contraction in consequence of cooling.

Origin of the grand outline features of the earth.

General view of the geological effects of the earth's cooling from a state of igneous fusion.

The plan of development in the geological history of North America.

When his *Manual of Geology* was published, in 1862, and thereafter, this work in its successive editions served chiefly as the medium for expression of his general views on geology.

The estimate which we should place on Dana's influence on the development of geology as a science has been so nobly expressed by Joseph Le Conte in his commemorative address before the Geological Society of America* that we cannot do better than quote it here:

> "As already said, the idea underlying all of Dana's geological work is that of the development of the earth as a unit. Before Dana, geology was doubtless in some sense a history—that is, a chronicle of interesting events; but with Dana it became much more, it became a philosophic history, a life history, a history of the evolution of the earth, and of the organic kingdom, in connection with one another.
>
> "For the first time there was recognized a time-cosmos governed by law as the true field of geology, as the space-cosmos governed by law is the field of astronomy. Before Dana, geology was the study of a succession of formations; with Dana it was the study of a succession of eras, periods, epochs, during which geographic forms and organic forms were both developing toward a definite goal. The underlying idea of his geological work, I repeat, was the evolution of the earth as a whole. . . . But while he held firmly and expressed clearly this idea of the evolution of the whole earth through all time, yet he recognized the impossibility, in the present state of geological knowledge, of carrying it out in detail in every part of the earth. He therefore conceived the idea of taking one best known and simplest continent as a type. He regarded North America as such a type-continent

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* Op. cit., page 41.

> and its evolution as an epitome of geological history. . . . the idea has become the working theory, not only for American geologists, but for geologists everywhere. There can be no doubt that Dana's ideas and Dana's work, especially as systematically embodied in his *Manual,* constitute a distinct epoch in the history of geological science."

We may add here that this conception of the growth and evolution of a continent through geologic time naturally induces the view of the permanency of the earth's great features, of its continental masses and ocean basins—a conception of geologic thought of today which we owe to Dana. He was also one of the very first of the paleogeographers, as shown by the maps in the first edition of his Manual.

No review of Dana's work in geology would be complete without mention of the *Manual of Geology.* Of this work four editions, as stated, were issued, the last at the very close of his life. Like his *System of Mineralogy,* it served to display in geology his genius in classification and organization of masses of facts and ideas into a coherent and logical whole and for the expression of his philosophic thought. Generations of classes in American institutions have received their education in geology, and in considerable part in biology and philosophy, through the medium of this work. Its educational influence, therefore, has been very great and impossible to really estimate. As a text for beginners in college classes, the book, however, considered from the standpoint of student psychology, is a very tough crust for children's teeth. In time it was replaced in this function, in part, by Le Conte's *Elements of Geology,* which was better adapted to this purpose. The condensation is great and, especially in the last edition, the total amount of matter presented enormous, so that it has become rather a handbook of geology, especially of America—an indispensable work of reference. It is, perhaps, not too much to say that nearly all American workers, prominent in science today, have received much, and in many cases most, of their geological training by means of this book, and not a few have had no other instruction than that gained by their individual study of the work. Had Dana produced nothing but this volume he would yet have served this science as few others have done. His more elementary texts have also had a wide circulation and have greatly helped in diffusing a popular knowledge of this subject; the *Text-book of Geology,* revised in recent years by Professor William North Rice, is still actively used.

IN ZOÖLOGY

Into this field of science Dana was impelled, so to speak, largely by the exigencies of the situation in the Wilkes Expedition. His preparation for zoölogical research from the standpoint of today must have been necessarily scanty, though we should not overlook the fact that some of his very earliest published papers were in the field of zoölogy, concerning spiders and crustaceans, in part in conjunction with others, and for which he drew the plates. This indicates he had made progress in zoölogical studies; he had also done some work in botany, but in the main he was obliged to educate himself in the field allotted him as he went on with his task. He thus became a trained specialist in a considerable part of the invertebrate field. As time passed his knowledge became wider and the preparation of his *Manual of Geology,* on the organic side, led him to obtain a firm grasp of practically the whole field of zoölogy in all its departments, especially with reference to its development and bearing on philosophic thought. He thus became one of the great naturalists of his day. His work at first was of a morphological nature, like other zoölogists of his time; but from the beginning one can see that he was never satisfied with the mere details of structure, and eventually he moved into much higher planes of thought.

In the writing and publishing of his first important work in this field, his report on the *Zoöphytes,* we see again displayed that organizing and philosophic turn of Dana's mind and his genius for classification. He was not content with a mere description of the species collected, but delved into the subject until he had clearly in mind all that was known upon these classes of animals and then proceeded to prepare a profound and philosophic treatment of them, involving a classification which is yet accepted essentially for corals. In doing this, as previously stated, he came in sharp conflict with the authorities at Washington, who wished him to confine himself to description of collected material alone; but, fortunately, Dana triumphed in the end and the volume was issued in the form he desired. The value of the publication, now one of the classics in the literature of zoölogy, was immediately recognized and gave Dana a standing as a naturalist of the first rank.

This was followed by his colossal work on the *Crustacea*, and to realize the effect produced by it upon his contemporaries we cannot do better, perhaps, than to quote what Darwin wrote to him about it in a letter given in Gilman's life of Dana:

> "I have experienced such great interest in many parts and have found it so suggestive towards my *Cirrepedia* work that I cannot resist expressing my thanks and admiration. The geographical discussion struck me as eminently good. The size of the work and the necessary labor bestowed upon it are really surprising. Why, if you had done nothing else whatever, it would have been a *magnum opus* for life! Forgive my presuming to estimate your labors, but when I think that this work has followed your *Corals* and your *Geology*, I am really lost in astonishment at what you have done in mental labor. And then, beside the labor, so much originality in all your works!"

After this Dana's contributions to zoölogy were shorter papers, mostly of a philosophic character, and the development of his views in the *Manual.*

During his studies on the Crustacea he was led to notice that in any class of animals, in proportion as they rise higher in development, so much more does the structure become devoted to the service of the head, to the department of intelligence. He saw that in crustaceans in the higher forms more of the appendages were used for this purpose and less for mere locomotion. In Dana's mind, so naturally given to generalization, this idea appeared a fruitful discovery and its application seemed of increasing importance; eventually, under the term of *"cephalization,"* he brought out the principle of the dominance of the brain in determining the structure of the animal organism. This general principle, though not today with such a broad development and so wide an application as Dana conceived it, is yet important in biological and also in philosophic lines of thought and research, so that we should recognize what we owe to Dana for first clearly recognizing and stating it.

Dana was slow in accepting the theory of evolution in the form stated by Darwin. Yet it is clear from his writings that not only was his mind moving along parallel lines, as indicated in part by what is stated above, but it was also accumulating facts and ideas that were carrying him toward that principle in its broader applications.

In the report on Crustacea, while he thinks that a species cannot be created by circumstances and physical forces, but must be the free act of a Divine Being, he yet remarks that "we may still believe the connection between the calling into existence of a species and the physical circumstances surrounding it to be as intimate nearly as cause and effect."

From this we may infer that the old idea that species suddenly appear by the fiat of a Creator, without regard to natural laws or conditions, no longer obtains in Dana's mind, but rather that the Divine Will manifests itself through the medium of natural means. He subsequently further defined this by stating, "a species . . . is based on a specific amount or condition of concentrated force defined in the act or law of creation";* but this referred to not only living organisms, but to inorganic compounds also.

If, however, we take this view, in connection with the recognition of the principle which has been mentioned above, we can appreciate how Dana had moved toward evolution without himself being aware of it. The principle of evolution is so universally accepted today and forms so fundamentally a part of our thinking, that it is difficult for us to realize a time when it formed no part of the mental outfit of science; we should do this, however, to appreciate how in some ways of thinking Dana was ahead of his time and how inevitable was his final acceptance of it.

Darwin's work on the origin of species appeared in 1859, but on account of ill health, as he himself states, Dana was unable to read it for several years. Gradually the conviction of the truth of this principle grew in his mind and, although he differed from others in some ways in regard to its application, he finally accepted it firmly, and in the last edition of his *Manual* he again affirms this belief. "Consequently, the law of nature, as regards kingdoms of life, is not permanence, but change, evolution."

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* Amer. Journ. Sci., vol. xxiv, 1857, p. 307.

Although Dana attained first rank as an active zoölogist comparatively early in life, as he also reached supremacy in mineralogy, he did not continue it as the chief field of his active thought. Both of these sciences, mineralogy and zoölogy, came eventually to have their chief interest to him in their bearing on his chosen field of mental activity—geology. And seeing from this how wide a range of knowledge his comprehensive mind possessed, it is easier to understand how he was able to approach this science from every point of view, from detailed work in any field to the broadest of philosophic generalizations, and to give to the whole a unity and cohesion it had not previously possessed. Of his contributions to science, on which in the future his fame will be found to chiefly rest, this, we believe, will have most distinction and importance.

THE AMERICAN JOURNAL OF SCIENCE

No statement of Dana's services to science, and to American science in particular, would be complete without mention of the part that he played in the editing and conducting of the *American Journal of Science,* which was for so long a time the only organ for scientific publication in this country, and which still remains, although the establishment of many journals in special fields of science and other foundations for scientific publishing have enabled it to restrict its field of activity, the means through which a large part of the scientific workers of the country naturally first make known the results of their labors.

Under the title of the *American Journal of Science and Arts*—the last part of the name having been dropped in later years—it was founded in 1818 by the elder Benjamin Silliman. In 1838 the younger Silliman became associated with his father, and in 1846, on the beginning of the second series of 50 volumes, Dana was added to the staff. He remained in service almost to the day of his death, since the number which contains the obituary memoir of him by his son also contains several notices of scientific works prepared by him. The elder Silliman retired in 1863, the younger in 1875, and was succeeded by Edward S. Dana, the present editor-in-chief. From 1850, until in the later years of his life he was relieved by his son, the chief burden of editing and conducting the magazine fell upon Dana. Any one who has performed this kind of work knows what a time-consuming and often thankless drudgery is involved in the endless correspondence, proof-reading, and other duties of editing a journal which, rain or shine, must appear, each number, at a stated period. But we must add to this that the *Journal* has never possessed any income beyond that afforded by the list of subscribers, and this income has never been more than sufficient to meet its expenses of publication. Consequently it has never been able to find a publisher who would assume it, and the financial responsibilities and risks have, perforce, been carried by the editors, who all these years, from the business point of view, have had only their labors for their pains. To consider only one aspect of it, it would seem to most that an enterprise of this nature would alone be sufficient to engage the time which could be spared from required duties, and it becomes a marvel how Dana, viewing also his physical condition for so many years, was able to carry this burden and yet accomplish what he did in other ways.

It was not, however, all of it mere drudgery without reward. By reason of the *Journal,* Dana kept constantly in touch in his correspondence with the best minds in the country, and this must have been in some measure an alleviation of the very retired life he was compelled to lead. It also afforded him a constant and ready means for the publication of his views on various topics, and by this and his notices of the work of others he was able to exert a wide influence upon scientific thought and work.

The maintenance of this journal, the cheerful giving of his time, thought, and labor to the service of others, and thus to science in general, is by no means the least of the benefits Dana conferred upon his own and succeeding generations and which should be held in grateful remembrance.

AS A TEACHER AND COLLEGE OFFICER

In considering Dana's career as a teacher, we must at the outset recall that he was already 43 years old when he held his first college exercise. It is not easy for a man at this age to begin an entirely new profession; forms of expression both in speaking and in writing have become more or less fixed and ways of viewing subjects and the approach to them hardened. It is one thing for years to have always been addressing and thinking on the plane of the most trained and advanced minds in the world and another thing to seek to set the imprint of knowledge on young and only partly formed mentalities. Teaching is in itself an art which can never be wholly reduced to a science; it is not sufficient to possess the requisite knowledge; one must also know how to impart it—a fact too often overlooked in the appointment of men to teaching positions. This art of imparting knowledge has to be slowly and patiently acquired; it is most easily learned in youth, and some have a greater talent for it than others; but, however great the talent, it must still be trained.

Thus we can see that in taking up college work as a profession Dana labored under certain disadvantages, but on the other hand he possessed undeniable qualifications for the work. Of great importance for a teacher, he had a most engaging and striking personality; he was a quick, eager, and incisive speaker; in addition to his great fund of knowledge, he had a wide experience of men and affairs, of travel and experience; he was full of enthusiasm; he lived a number of years under naval discipline, and in his youth, during his Mediterranean voyage, he had gained some experience in instruction.

Therefore, if we bear this in mind, and the great reputation he had already achieved, we can understand why from the beginning he produced a great effect upon his classes, and, although at first he had much to learn and no doubt often went far over his students' heads, he never failed to hold their interest and attention. At first he gave instruction in both mineralogy and geology, afterwards in the latter science alone. He also gave occasional lectures in other subjects which interested him and with which his studies had brought him into close touch, such as evolution. A remarkable lecture which he sometimes gave was on coral islands; his enthusiasm, eloquence, and remarkable gift of vivid description never failed to carry his audience with him, and even into his later years to hear Professor Dana give this lecture was one of the events of a course in the university, as the writer can testify by personal experience.

Dana's contact with undergraduates in the earlier days of his teaching was not a close one; in his day geology was not an applied or technical science, as it has become today; it appealed in academic circles purely from the cultural standpoint, and the sciences were advancing slowly to importance in this last aspect. Thus, very fortunately for the rest of the world, he was not required to carry a heavy schedule of instructional work and could devote much of his time, when his health permitted, to other things, with results that have already been sufficiently indicated.

But the testimony of those who sat under him in these classes and which has been put on record is that he aroused great interest in his subject; that his standard of work and accomplishment was high; that the effect he made as a man and a teacher remained strongly imprinted in after life, and that young men obtained from him much more than was to be found between the covers of his text-book.

He was in the habit of giving occasional field excursions in the environs of New Haven to his college classes, in which others who were interested were invited to join. These were well attended and greatly enjoyed. The amount of strength and nervous energy he put into these, especially in getting about from place to place, was remarkable, and even the most athletic student found one of them no idle ramble in the country, but a real business affair, a tax on his mind and muscle. It was on one of these excursions, as mentioned at the beginning of this memoir, that the writer first came in contact with him, and the remembrance of it is as clearly cut as a cameo on its background.

In 1885, when elective studies began to be more extensively opened to undergraduates in the college, he offered a more advanced course in geology to seniors. This proved very successful and he was able to continue it for a number of years. Occasionally Dana had more advanced students who worked under him, men who were taking up his science as their life pursuit. Some of these have risen to distinction, and at the time of his death they put on record their appreciation of him as an instructor and guide.* One point they all mention in common, and that was the openness of mind which Dana insisted they should bear toward the reception of scientific views and theories. As he was opposed to a dogmatic attitude himself and ready to be converted to a new view when in his judgment the facts indicated its correctness, so he desired his students to be of similar mind; he wished no authority in science to be recognized.

Although as a college officer Dana was not able to take a very active part in the management of routine affairs and the transaction of general business matters, he was, nevertheless, of great aid in various ways. His influence, from his commanding position as a scholar and scientist, was, naturally, great, and he always exerted it in the direction of progress and development, especially in the function of science in education. His encouragement of his younger associates in their work and the benefit of his advice, freely given, was of great value to the university.

The late Professor George J. Brush, the mineralogist, for so many years the director of the Sheffield Scientific School and leading spirit in its development, has a number of times spoken to the writer of the help afforded the institution, especially in its early days, by Professor Dana, in his advice and ready sympathy for its plans and aspirations. The late President Dwight, of Yale, in his noble memorial address upon Professors Dana and William D. Whitney, also gives a full appreciation of the service to the institution which the former afforded by his life and work, especially in his stimulation of the university ideals.† Others have spoken along similar lines.

When the University Museum became possible, through the munificence of George Peabody, he gave much time, thought, and advice to planning the building, and upon its completion, in 1876, he was active in the arrangement of its exhibits, especially in mineralogy. Thereafter it became in a large measure his home, and those yet living who knew him will always naturally associate him in their minds with his office and lecture-room in the edifice. It is this memory which causes one of the regrets at the necessary recent demolition of this building and the proposed erection of the museum upon another site.

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* See articles cited, pp. 41 and 42.

† Op. cit., p. 41.

CONCLUSION

Of the personal characteristics of Dana, of which it is appropriate to consider in a memoir of this nature, sufficient has been already said in the foregoing pages. It may, however, be added that he was very fond of music; he had some skill on the flute and guitar and composed a number of pieces; music was often a rest to him in his later years. He was naturally of a social disposition, and those who knew him in younger days have testified that he took pleasure in the gathering of friends and in intercourse with others, until his health demanded a strict limitation of such occasions. All his life he was a firm believer in the Christian faith and a constant attendant of the college church.

It is, perhaps, needless to say that in the course of his long life many honors were conferred upon Dana, but to make this record complete it may be mentioned that, among others, he received the honorary degree of Ph. D. from the University of Munich in 1872, of LL. D. from Amherst College in 1853, and from the universities of Harvard and Edinburgh in 1886. In 1872 the Geological Society of London conferred upon him the Wollaston medal in recognition of his work in Mineralogy and Geology; in 1877 the Royal Society of London awarded him the Copley medal for his Biological, Geological, and Mineralogical investigations, and in 1892 he received from the Boston Society of Natural History the Grand Walker prize of $1,000 for distinguished services in Natural History.

Of this Academy he was one of the original members and also a vice-president; but, unfortunately, his health did not permit him to take that active part in its meetings and management which his abilities and distinction would have naturally suggested. Of foreign academies he received membership in a great number, among which may be mentioned those of St. Petersburg, Vienna, Berlin, Munich, Stockholm, and Budapest; Academy of Sciences in the Institute of France and the Royal Societies of London, Edinburgh, and Dublin. In this country academies or societies in Boston, New York, Philadelphia, and Washington honored him. He was president of the American Association for the Advancement of Science and delivered his presidential address at the Providence meeting in 1855. He was also president of the Geological Society of America in 1890. With all his honors, Dana was one of the most modest and unostentatious of men; he never expected them or spoke of them, even in his own family.

James Dwight Dana was one of the great naturalists, one of the greatest of geologists, and one of the leaders in the development of science on which our intellectual and material progress rests. We may have a just pride that our country produced him and that he was one of the founders of this Academy. May his memory ever serve us as an inspiration!

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E. W. Hilgard

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OF

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1833-1916

BY

FREDERICK SLATE

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Eugene Woldemar Hilgard was born at Zweibrücken, in Rhenish Bavaria, on January 5, 1833. At that date his father, Theodore Erasmus Hilgard, a noted lawyer, held an important position as Chief Justice of the Court of Appeals of the province. His mother, Margaretha Pauli, was a descendant of that Pierre Toussaint de Beaumont who was court preacher to Marguerite, Queen of Navarre, and subsequently canon at Metz, having fled from France during the persecutions of the Huguenots. His son Daniel, known in ecclesiastical history as Tossanus, was court preacher at Heidelberg and afterwards rector of the university there, in which his grandson, also Daniel, in due time became Professor of Theology. The daughter of the latter married Reinhold Pauli, the great-grandfather of Margaretha, who traced her descent otherwise, too, from generations of clergy.

Theodore Hilgard, himself descended from a long line of ministers of the Lutheran Church, and having been born during the impetus of the French Revolution, was of pronounced liberal tendencies. He opposed stoutly the proposal to supersede the *Code Napoléon* by the illiberal laws of the *ancien régime,* and determined finally to resign his office, though standing in the fullness of a successful career. Having rejected repeatedly flattering offers from the government at Munich because the posts tendered would have removed him from a sphere of liberal activity, he reached at length the fateful decision to emigrate to America, the land of liberty, with his family of nine children, among whom Eugene Woldemar was the youngest. In taking this step he followed the lead of a number of relatives and political sympathizers who had already migrated toward the "Far West."

In the autumn of 1835, then, this Hilgard family entered upon the long journey, whose first stage in those days was a drive of fourteen days to Havre, their household goods (including a grand piano) accompanying them on freight wagons. After four weeks' wait at that port, they embarked on the good ship *Marengo* bound for New Orleans, and celebrated Christmas eve by arriving, at the end of sixty-two days. Fortunately a steamboat was soon to leave for Saint Louis, a risky voyage of ten more days against heavy drifting-ice, during which the subject of the present memoir recorded his third birthday.

A group of cultured German families, largely exiles for political reasons, were already settled in the neighborhood of Belleville, Illinois, the county-seat of Saint Clair County; and that group the Hilgards joined, establishing themselves on a farm. The colony became known as the "Latin settlement" and its members as "The Latins," on the popular supposition that they actually spoke in Latin or were at least competent to speak it. In truth, however, it was the German language that remained predominant among these settlers and their children, because new German immigrants kept swelling their numbers, and because there were at that time but few educated American families resident around Belleville.

The former chief justice did not resume any legal activity, finding the common law and the court practice by precedent unsuited to his taste; so he returned to literature as an early love, to which he had once thought of devoting himself exclusively. Recalling his predilection for the classics, he undertook presently to make metric translations into German of selected Greek and Latin poets: Ovid's Metamorphoses (printed at Belleville) were among the first of these; and later he finished a part of the Odyssey, which had attracted him as being related in some measure to his own wanderings. He translated Moore's Lalla Rookh also, and issued a small edition for private circulation. While engaged in such work it was natural to share it with the family by reading and discussing portions of it; so in this classic-poetic atmosphere, infused with music and other art, and under strong influence from their father's advanced views about politics and social questions, the children's lives must have been shaped in unusual ways that were to bear future fruit. As this account progresses, that exceptional nurture will offer the key to much that set Eugene apart among his fellows for maturity and for strength.

The four Hilgard boys found themselves rather isolated, since no other "Lateiner" lived in the immediate neighborhood. Their father thought it inadvisable to send them to the local public school, which was still quite primitive, but instructed them himself instead in mathematics and the languages, with aid from the older sisters, especially in the case of Eugene. Having been educated largely in French institutions, the father was inclined to insist strenuously that the children should all learn French while young. After-dinner readings in that language constituted a regular exercise, and there were two fixed days a week when all communication was to be in French. Neither form of this discipline was entirely popular; the reluctant boys schemed to evade it, escaping to the woods and there in reprisal relaxing into the dialect of the Palatinate which was taboo at home. Apart from some hunting, gardening, and a substratum of farm work such as the conditions required, the occupations and the games of conventional boyhood found only a subordinate place in this mode of living. The woodlands and prairies of the region balanced fairly their rival attractions as fields for botanizing and for collecting insects, and an extensive and varied home library offered an opportunity for spontaneous reading or consecutive study. In the pursuit of natural history, Eugene and his brother Theodore, who was five years older, soon became very assiduous, being specially stimulated by a borrowed copy of Oken's Natural History, and helped, too, particularly in their botany, by a cousin resident in Saint Louis.

This almost ideal state of things might have continued for the boys until the time of natural flight from the parental home but for the intervention of that Nature whom it was then the day-dream of enthusiasts to approach once more through return to simple living. That intervention here took the form of swarms of mosquitoes with consequent fever and ague, whose close interconnection was, however, at that date scarcely suspected. An epidemic of typhoid fever went progressively through the family, of which the eldest sister died. The disease attacked Eugene last; there was a severe relapse and from this time forward for some years he was to suffer during several months of each summer from fevers—tertian, quartan, or quotidian, or from all combined. It was inevitable that habits of study were much interrupted, especially when the inroads of ague were found to affect the eyes. Meanwhile mosquitoes were allowed free access to such patients, fumigations with pumpkin leaves being the utmost defensive measure employed against them, unless we may add the daily diet of quinine.

In 1842 fate struck again with the death of the mother after a lingering illness; so, naturally, this threw the management of the household and the care for the younger members of the family into the hands of the elder sisters.

In 1846 the favorite brother, Theodore, left home to study medicine in Europe; and this loss of a sympathetically close friend conspired with physical depression attendant upon Eugene's illness, inducing a state of mind that was probably detrimental to his health, already weakened by a persistent obsession with fever and ague and its concomitant troubles. The disability of the eyes increased, as did the chafing against breaking off study. He persevered with work in botany, however, and gradually acquired a knowledge of physics and chemistry from the "Lehrbuch" of Müller-Pouillet and Gmelin's "Handbuch," contriving such chemical and physical experiments as his limited resources permitted. The fundamentals of these two sciences and many of their important details, thus absorbed without any teaching, proved later to be of material assistance to Eugene as a student, placing him in advance of those who were his equals in academic age.

The physicians at last acknowledged the danger of remaining longer in so malarial a climate, and the father decided that Eugene should go where he could attend lectures at least, since he was barred from reading freely. So he left home in the summer of 1848 with his oldest brother, Julius, then returning to Washington, where he was assistant in the U. S. Coast Survey. As a first impression of serious travel, then not so smoothly easy as now, this journey, of course, left a profound impression. It occupied a full week, being made by steamboat to Louisville and thence to Wheeling; by stage to Cumberland, and by the newly opened railroad to Relay House and Washington. During a stay of four months in that city Eugene met some of the men nationally prominent in science, notably Joseph Henry, the first Secretary of the Smithsonian Institution, and his assistant, Baird; also A. D. Bache, then Superintendent of the Coast Survey. The youth thus introduced to them was not yet sixteen; he felt embarrassed, moreover, by a consciousness of that foreign tinge in his English speech which the German of childhood had left and which he removed fully only by persistent effort. Altogether, he doubted much whether these older men were at all impressed. Yet the sequel showed, through the ready furtherance of his objects at every return to Washington, good proof that at least some of these leaders recognized in Eugene Hilgard the quality that placed him among their logical successors when his ambitions had unfolded into a career.

The time spent in Washington was partly devoted to collection and study of the local flora; but a certain lack of opportunities to attend lectures decided Eugene, in November, to move on to Philadelphia. There he heard the evening lectures at the Franklin Institute by Professors Booth and Fraser and others; also the winter course in chemistry given by Professor Semple at the Homeopathic College. The latter soon discovered that the young student was fitted to act as lecture assistant and engaged him. This duty gave much valuable experience in manipulation and in the preparation of rarer compounds, as well as the stimulus due to personal contact with the professor and sharing his thoughts. Then, besides, since the newer aspirations were not finding full outlet in the experimental work at the college, the younger Hilgard established for himself a private laboratory in a garret room. Here he practiced also electrotyping and photography, for which he contrived his own appliances; and thus the severe winter passed in busy and profitable occupation.

A visit to Professor Booth's laboratory, at that date the only one in this country where students were systematically taught analytical chemistry, brought the suggestion of going without further delay to Germany, where such studies could be prosecuted more advantageously. This plan having received the paternal approval, passage was secured on the steamer *Hermann,* to leave New York in March, 1849, for Bremen, whence the journey would be continued to Heidelberg, where the brother, Theodore, was then a student. With a self-reliance incidental to sixteen completed years, the trip to join the steamer was entered upon alone; but it is recorded how awed the traveler found himself by the dangers of the big city, how he sought refuge from them overnight on board the boat, and was glad to sail and leave them behind the next day. When nearing Bremen the *Hermann* was halted by a Danish cruiser and searched for contraband of war, the Schleswig-Holstein conflict with Denmark being then in progress; and this occurrence was held to augur more excitements to come, for the revolutionary movements of the previous year were known to be flaming up again for the suppression of "princes, potentates and powers," and making their call too for recruits. From Bremen the remaining stage to Heidelberg by way of Cologne and the Rhine steamers was completed safely, and the reunited brothers, Eugene and Theodore, were able to celebrate their first evening together at a large "Maiwein Kommers." This was for Eugene his first foretaste of German student life.

At the university work in Professor Gmelin's chemical laboratory was begun at once with zeal, and supplemented by attendance upon Bischoff's botanical lectures. But as time went on the general conditions within the university and outside it fell short in several respects of making unreserved appeal to this keen-minded young observer. Some of the lectures heard proved to be perfunctory and uninspiring, or the lecturers failed under test to reveal the scientifically open mind. He could muster but scant sympathy either for the false ideals and the ritual of the "Korpsstudent;" nor did he discover political maturity under the lacks in competent leadership and coherent purpose betrayed by the forms that democratic strivings took. Such impressions and experiences, then, disappointed in some degree the expectations implanted by the early influence of his father, and they consequently gave a certain tentative character also to the effort of the next two years. Eugene Hilgard was later inclined to trace in them a period of orientation; of search for some combination that would yield a satisfying vocation based upon adequate preparation for it. Such deliberate approach circling round the lifework finally chosen was, however, not uncommon among those men of an older generation who arrived at distinction. There was nothing leisurely or desultory in the process; it was, on the contrary, of necessity aggressive and strenuous, because each man was compelled to break in large measure an individual path. There is good cause to doubt whether the same toughness of fiber can be developed so fully on the present highways laid out and ready to lead into some intensive early specialization.

Eugene and Theodore Hilgard left Heidelberg in the summer of 1849, with no plan that looked beyond an outing for recreation and a visit to their native Palatinate. But at Karlsruhe they came among the uprisings that put the Grand Duke of Baden to flight and led to the establishment of a provisional government, and on crossing the Rhine they found great confusion prevailing. Much enthusiastic shouting for equality and liberty there was, to a loud accompaniment of drums and fifes; much aimless discussion in meetings as well, but a noticeable absence of definite action, except that rudely armed peasants were seen drilling everywhere in squads. With the support of American passports and their locally influential family name, the two travelers opened their way easily past such sentinels and guards as they encountered and reached Speyer, where they found their cousin, Fritz Hilgard, in power as civil commissary, or governor over the eastern Palatinate. His plain forecast of anarchy in the immediate future confirmed their own observation and inclined them to adopt his counsel, according to which they should at once turn back to Heidelberg, make their route thence to Switzerland, and abide there while these troubled times lasted. In fact, they did witness later at Zurich the disarming of the German revolutionary army, and they met again their cousin there, now an exile, escaping sentence of death. Thus some compulsion arising from political conditions determined the migration to the University of Zurich for Eugene and his brother, which was the next stage in their progress.

At Zurich Eugene Hilgard found Professor Oken in person, the charm of whose Natural History had incited to study in the far-off American home; in geology he worked with Escher von der Linth, in chemistry with Professors Löwig and Schweitzer, all notable men. Here, not otherwise than in Philadelphia, he still found himself overtopping his contemporaries in the strength given by preparatory study, and he was soon selected by Löwig to be assistant in the lecture-room and in laboratory investigations. These and similar activities rounded out three semesters at Zurich, which were looked back upon as the most enjoyable of the growing student's training. The next step carried Eugene, in 1850, via Dresden, where a married sister had meanwhile come to reside, to the Mining Academy at Freiberg for advanced study in mining and metallurgy. So he parted company with Theodore, who was proceeding to the University of Vienna, whose medical school stood then, as now, in high repute.

In those years the Freiberg Academy was at its best, with Plattner, Breithaupt, von Cotta, Weisbach, in the chairs of metallurgy, mineralogy, geology, engineering, as well as prominent men in other departments. While as a student he could not but prize such opportunities and avail himself of them industriously, the young man in Eugene Hilgard found the local life much less attractive than at Heidelberg and Zurich. Not only did he miss sorely the beauty of landscape in his surroundings—Freiberg being no exception to the proverbial rule that mining regions are bleak—but he experienced another, and for him more serious, defect in the daily living. There were unsocial conditions prevailing in the community; antagonisms between the garrison and the student body, jealousies of spirit, setting academy against the universities. The effects of the latter especially galled the student with a record of four university semesters, who stoutly refused to acquiesce in the status of "Fuchs" proposed for him among men of little liberal education and shorter apprenticeship than his. So Hilgard was out of tune with the majority of his fellow-students, had some sharp differences with them, and was thrown for his closer associations upon the small body of foreigners, among whom were several Americans.

But he grew into intimacy with Professor Plattner, in whose blowpipe methods of chemical analysis he became so strongly interested that he developed them with important expansions subsequently. In the laboratory of Professor Scherer he carried through an investigation into a new double sulphate of iron and potassium. In his own quarters, moreover, other researches were developing; namely with organic compounds, one of which might have ended life and study together, when hydrocyanic gas was unexpectedly liberated from oxamid and inhaled. Fortunately, though, the effect at the time was nothing worse than a few minutes of unconsciousness, and no further results of the accident appeared. This period shows other risks incurred, however, whose consequences were not so transient, exposure to which was attendant upon a practical course in the smelting works at Muldnerhütte undertaken during one vacation. Here there were fumes of sulphur, arsenic and lead, from the furnaces that the student was set to feed, causing a troublesome cough. In addition, the insidious quicksilver vapor leaking from the condenser in a distillation of amalgam nearly overcame Hilgard on one occasion. And needing then to be sent to a doctor for treatment, he received unawares the shock of being pronounced unfit physically to become a "Hüttenmann." This verdict was presently corroborated by his brother Theodore, whom he visited at Vienna, and who on all scores advised him rather to follow the out-of-door life of a geologist or a botanist.

This crisis, to be sure, was no more than an accentuated recurrence of previous warnings. The persistent attacks of malaria during the critical years of growth had been tenacious in their after-effects, bringing on exhaustion under any severe task; for instance, in Zurich once, when Theodore was obliged to prescribe as a tonic a trip through the Bernese Highlands. Quick improvement in the bracing air had been clearly apparent then; for just one climb from Lauterbrunnen across the Tschingel glacier to Kandersteg, though begun with aching head and eyes and accomplished, forsooth, only under the repeated spur of "Kirschwasser" from the guide's flask, had banished the bad symptoms effectually. Such marked success had encouraged a continuance of the plan throughout that vacation, during which the brothers reached points like Zermatt and Chamouni, Eugene finding himself at the end of the trip able to use without hindrance eyes to read and brain to think. Therefore, it was natural that the prescription should be renewed for the following summer, with botanical collecting added to infuse its zest into these journeyings, which now included a passage from the Grimsel over the Aarglacier to Grindelwald by way of Stralegg Pass—a route then rarely attempted. This course of health-giving exercise in mountain air had been repeated in the summer of 1850, when Judge Hilgard arrived on a visit to Germany and among other diversions climbed the Righi again with his two sons.

In view of that unbroken series of good results, it is no wonder that the earnest brotherly counsel again in 1851 was to take to the Alps and seek restoration from the weakening experiences at Freiberg. Accordingly, Eugene Hilgard turned his face to Switzerland once more, though not to the high mountains this time, and made a tour of two weeks, alone and on foot, in the region round the Lake of the Four Cantons. Remarkably improved in vigor, he returned then to Heidelberg, being moved to this decision by the recent appointment of Robert Bunsen, who had been made Gmelin's successor, and was already a power to draw students round him. The known breadth of Bunsen's interests, that not only covered chemistry, but also led him to discoveries in physics and geology, on the one hand appealed attractively to Hilgard's mental habit; and besides, all three fields seemed to bear, each with its own importance, upon his future in so far as that had begun to assume definite outline. We are aware how the long years in store were to bring gradual realization of these inclusive plans for a broadening range of activity. After only a few weeks in the atmosphere of the newly-inspired laboratory, the decision was reached to take the degree of Doctor of Philosophy under Bunsen's auspices; and in due time, on October 3, 1853, the candidate was transformed into Doctor Hilgard. It bears clearest testimony to the capacity and the sustained zeal with which the preparatory studies were carried through, that the degree was bestowed with the highest honor, *"Summa cum laude,"* upon a student who had not yet completed his twenty-first year, and who had not undergone any apprenticeship of the baccalaureate.

There was only a select quartet of students admitted to the advanced work: C. Bohn from Leipsic, Kjerulf from Christiania, Landolt from Kiev and Hilgard. Their laboratory was primitively quartered in the corridor of an old convent, but they enjoyed that essential advantage of familiar relations with the professor, and were receptive sharers of his contagious enthusiasm. Bunsen's reputation, to which his appointment in Heidelberg was due, had been built upon his investigation of kakodyl that had opened up a series of organic compounds and upon his analyses of the waste gas from blast furnaces. In 1851 he was more specially engaged in perfecting the titration of iodine solutions with sulphurous acid, together with the general methods of gas-analysis; and he easily induced Hilgard to adopt as his doctor's thesis some inquiries into the complicated process going on in a candle-flame, which the professor characterized as a miniature "Hochofen." Under the professor's general guidance then, the young student was left free to attack the details of his problem with entire independence. Under the self-reliant conditions of those days, too, he was obliged to do much toward constructing, graduating and calibrating his own apparatus, so that he acquired incidentally a skill in glass-blowing that served him well through after-life.

In this thesis Hilgard distinguished and defined four parts in the flame of a candle or lamp, of which only three had been usually identified, and the four corresponding processes. Analysis of gases from the inner cone proved, contrary to prevailing impressions, that the air penetrates to the central dark cone abundantly, instead of burning the gases on the outside only. It was established that the heat of the outside veil, or zone of complete combustion, while gasifying the fuel, acts also somewhat like a red-hot tube in forming ethylene, marsh-gas and hydrogen. Water and the two oxides of carbon were found increasing in proportion as the higher parts of the flame are reached, until the high temperature causes the liberation and ignition of the carbon to which luminosity is due in flames from tallow and wax. The blue tint at the base of any flame was shown to result from instantaneous oxidation under unrestricted access of air that gives the colors of a mixture of hydrogen and carbon monoxide. The blue cone of the blowpipe's oxidation flame is then simply a prolongation of such a "blue cup" at whose tip the highest temperature exists. Bunsen gave high praise to the investigation, whose general conclusions were fully sustained when Lunge reviewed them, having simplified the conditions by using illuminating gas for fuel.

The candidate filled two years busily with preparation, supporting his major line of work with physics and mineralogy, and the ordeal of the examination at length arrived. We are assured that the test was endured with unshaken composure in the stimulating presence of Bunsen; and without any sense of difficulty, though von Leonhardt, the mineralogist, was rated an examiner formidable in his capricious demands. Associated with Hilgard for the examination was L. Carius, lecture assistant to Bunsen, and the two candidates arranged for a joint "Doktorschmaus," the usual celebration of success. But here Carius had presently to represent both as host, his companion in honors being once more in weak health from overwork and obliged to desert the festival early. It would seem, indeed, that a breakdown might have overtaken Eugene several months before had not his sister Clara (already widowed) been resident then in Heidelberg and able to give him affectionate care.

On the day after the examination, the new Doctor deemed it advisable to consult a physician about his case, who decided that, because of a persistent cough and general poor condition, Hilgard ought to seek a Mediterranean climate promptly, suggesting the Island of Elba. But after conferring with his brother and sister, a journey to Malaga was substituted, where there were family friends who could be helpful if need arose. Some hovering suspicions of consumption made the good-byes among the Heidelberg acquaintances rather serious, but the patient himself seems not to have lost confidence. Taking the manuscript of his thesis with him for a final revision, he started southward by way of Zurich, and after a few days spent with friends there he went on through Lausanne, Geneva, Lyons; thence by steamer to Avignon and by railroad to Marseilles, making the trip at leisure in order to husband his reserves of strength. Embarking on a Spanish steamer that made unhurried halts at coast ports, the traveller was given time to look about him at Barcelona, Valencia, Alicante and Carthagena, beside like opportunity at Marseilles during an enforced wait of a week before sailing. After leaving France, however, an entire ignorance of Spanish limited his spoken inquiries to a priest on board who could use Latin and to a German steward, so observing eyes had double duty. That voyage offered Dr. Hilgard a first experience of arid regions and of their irrigation systems, whose peculiar conditions were destined to become so familiar to him subsequently in California, to the successful control of which the matured professor was later to make many valuable contributions. At Alicante the report ran that no rain had fallen in three years. The country must have looked unbearably dry by comparison with Northern Europe. It was noted that the only representatives of green wild plants were cactus and the dwarf palm, and how the peeled stems of the latter were locally esteemed a delicacy, though astringent as unripe persimmons!

The date of landing in Malaga was deferred by all these stops until the middle of November. Then came undelayed recourse to a tried physician, whose diagnosis could scarcely have relieved apprehension, for his prescriptions were recognizably directed against tuberculosis, and the dictum uttered to the friends of his client allowed perhaps three months for the distressing cough to complete its evil work. Unaware of the full gravity of this opinion, Dr. Hilgard set about securing accommodations where only Spanish could be spoken, in order that he might make rapid advance in adding this language to his repertory. Then he buckled down to putting the last touches of revision to his thesis and dispatched the manuscript in final form to Bunsen in February.

This winter taught the usual lesson about the discomforts of that season in a climate deceptively reputed tropical on the evidence of its summer heat. In lodgings upon a third floor and opening by draughty sash-doors upon an outside balcony, the delicate lungs could not well be protected from the air that was often chilled by snow lying thick upon the cathedral's domes. For bodily warmth one might muffle oneself in wrappings of bedclothes, since the charcoal brazier only aggravated the cough with its fumes and failed to heat the room. With the arrival of spring, however, there came also a noticeable improvement in health, that allowed excursions in the environs of Malaga, with good reward through the exercise and in collecting fossils and plants. In those times such walks were attended with some risk if extended far outside the city; of robbery at the least, or even of being held for ransom by real bandits who made sporadic raids from their strongholds in the mountains of Ronda, that were one headquarters for smugglers. Yet nothing untoward befell our exploring geologist and botanist, though he saw his footsteps dogged now and then by suspicious characters. Rather he found himself continually amused by the primitive ignorance of the country folk about any foreign lands, and by their belief in the geological hammer and the plant-press as some uncanny outfit of a "medicine man."

These habitual rambles fell doubtless in a critical time to put aside certain dangers and to yield permanent physical benefit. Nevertheless the scale did not turn decidedly enough toward betterment to justify an immediate return to America with the object of striking into some scientific career there. So to give himself fuller occupation, and as a partial means of support besides, Dr. Hilgard gathered a group of pupils in assaying, undertook to construct for a college a Bunsen battery of fifty cells, and devised on a commercial scale a plant for the distillation of essences from roses and from orange blossoms. His alert mind was of course extracting valuable experience from every activity, no matter how temporary, and he was acquiring quickly that full acquaintance with Spanish language, customs and society which helped to make him remarkable afterwards for cosmopolitan tone as well as for command of scientific horizon. We should not understand those traits in him adequately, unless we had dwelt at proper length upon the adventurous years that were ripening them.

With such aims in view, it was natural to accept introductions into the good families of Malaga; among others into that of Colonel Bello, retired from the army, whose home was noted for many a charming evening of "tertulia," rendered especially interesting by the musical talent of his only daughter. Here the young doctor was able to contribute with his collection of German music—in those circles a novelty at that date. And so he came into intimate contact with Spanish life, met profitably many people, and gained fluent control of the language. Some six years later the señorita Bello became his wife.

By the spring of 1855 his better health warranted the decision to return to America and enter seriously upon his lifework. But he determined to visit the Alhambra before leaving Spain, and elected to go on muleback in the company of an ordinary mule-train, coming back to Malaga though in the regular stage drawn by ten mules kept at a constant gallop, and found the trip both ways full of novelty. At the ancient royal town of Alhama he chanced to witness an old-fashioned peasant dance on the broad ramparts. Near Velez he saw for the first time fields of sugar-cane. There were two whole days at Granada, spent in roaming through the Castle and about the city. Here he could vouch for the survival of an old custom making boys free to throw stones at whoever appeared on the streets in foreign garb. On reaching Malaga again, being anxious to cross the ocean without further delay, Dr. Hilgard ventured to engage passage on a schooner of four hundred tons bound for New York, though its accommodations were poor. They were to take on their cargo of cork and salt at the port of Setuval, not far from Lisbon, and this circumstance afforded opportunity for a week's stay in that capital and its surroundings. Thus he was enabled to visit the Castle of Penna at Cintra and examine its beautifully chiseled walls; also to inspect that slender stone arch in the neighborhood, whose flexible construction had passed safely through the earthquake of just a century before which in Lisbon itself was recorded by the modern straightness of the streets.

Persistent headwinds were encountered on the ocean, so that the captain was induced to shape his course more southwest than usual. In that particular year this route happened to bring the vessel among the clinging seaweed of the shifting Sargasso Sea, against which the sails were powerless in the light tradewinds. But even this obstruction could be condoned, since it made possible some study of the varied fauna of the seaweed, including the "fishnests." Passing south of the Azores, they turned northward off the coast of Florida and landed safe in New York on July 4, 1855, after thirty-five days at sea. The fossils and plants collected around Malaga, it is said, would fit no schedule of the customs officer, who was at last puzzled into admitting them duty-free. This unconventional arrival in New York, in sharp contrast with an insipid following of some worn track, was in significant harmony with the whole period that it closed; years of personal initiative and of development from within, crowned now with a distinguished doctorate from the leading chemist of his day.

On reaching Washington, since no desirable permanent position offered itself, an arrangement was made, at the suggestion of Professor Henry, whereby Dr. Hilgard occupied a room at the Smithsonian Institution and could at least continue without loss of time his chemical researches. But this plan was quickly interrupted by a telegraphic summons to Hartford, Connecticut, to meet there Dr. Barnard, professor of physics at the University of Mississippi. He proved to be in search of an assistant to serve with the State Geologist, Harper, who being also professor of geology at the university, seemed unable for that reason and others to progress fast enough in the work of a geological survey. The salary offered the assistant was very moderate, and candid hints were let fall that relations with the future chief might be none too smooth; moreover, scientific colleagues were ready with condolence about the absence from that region of those palæozoic formations which were then occupying almost exclusively the minds of American geologists. Nevertheless, it was plainly an opening field for real employment, and the service was accepted.

Hilgard started southward a few weeks later from Washington for Oxford, Mississippi, by the Baltimore and Ohio railroad that had surmounted the Alleghenies during his absence abroad, stopping by the way, however, for a few days at New Harmony, Indiana. Here Dr. David Dale Owen with some assistants was then elaborating the results of the geological and agricultural survey of Kentucky and Arkansas. He received the visitor so genially, and was so generous in imparting the methods established by his wide experience as best to pursue in such surveys, that he made the visit permanently fruitful. He emphasized especially the need of close attention to the soils and other agricultural features upon whose proper recognition both the practical utility and the popular encouragement of such surveys would depend, particularly in Mississippi, that was not likely to be productive of much mineral wealth. From Owen was acquired, too, his always valuable scheme for soil analyses, and altogether his counsels of an expert were effective to mark out the first lines for the starting of Hilgard's work. Leaving New Harmony the journey was next continued by steamboat to Memphis, and completed by a stage ride of seventy miles to the site of the State University at Oxford. Here Hilgard was to make his headquarters until the transfer to Michigan in 1873, except for a brief residence in Washington toward the close of 1857, for a summer visit to Europe in 1860, during which he claimed his betrothed in Madrid, and for some disturbances during wartime. Here his three children were born. Entering upon this important stage of his career as a young man scarce twenty-two, those eighteen years of his future were to mature his powers through a varied professional activity involving many side-lights on politics and other aspects of human nature. Those were days of pioneer enterprise, hampered by oblique or halting movement toward any scientific goal, until public opinion in a provincial and uninstructed community could be educated into moral and financial support. Hilgard's own transition between the beginning and the end of this period—shifting his main active interest from geology itself to agriculture in its geological connections—may be read as a reaction upon himself of the educational campaign that was engaging his effort. His main undertaking belonged to an era that afforded fewer good models and that found scanty precedents to make plain sailing. His measure of true success in rendering distinguished service to his State, and at the same time building up a nationally recognized reputation, was achievable only by such alliance as his of sanguine young manhood, unusual training, and zeal for his profession. Other men might have been daunted by the difficulties of the situation and its crudities, or have grown cynical under repeated disappointment in human nature. In all these relations it seems probable that Hilgard's training, because it was foreign, must have helped him to a certain detachment that would favor freshness in attack and in conception of aims.

The Geological Survey of Mississippi had been authorized by act of legislature as early as 1850, being projected then rather hazily as a sort of complete Natural History Survey. The duty of organizing and directing it was at first superposed upon the professorship of chemistry (or of chemistry and geology) in the university, whose incumbent was Millington; a too familiar composite scheme for overworking one man into ineffectiveness. A first attempt to create the separated office of State Geologist met with failure in 1855, though recommended by the university trustees, and the better fate of the movement in January, 1857, as we shall see, was rather an incident of a political manœuvre, than due to gain in public insight. The financial provision was inadequate, as usual with such work; three thousand dollars per annum originally, while the legislature remained habitually more ready to enlarge the plan and the responsibilities of those placed in charge of it than to appropriate funds on the necessary scale. Naturally, therefore, beginnings could be developed but slowly, yet a good introductory report was got together for printing in 1854 by Professor Wailes, of Jefferson College, Mississippi, who had been secured for an assistant to the nominal director. This report, entirely of geological character, gave evidence of a creditable start toward classifying the cretaceous, tertiary, and quaternary areas of the State, and figuring the collected fossils. When Millington at this juncture resigned his professorship, and consequently these added charges also, it would have been advisable to appoint Wailes his successor. But another candidate, more pretentious though less fit, seized the vacant professorship, and so became automatically the head of the survey. He was that Harper to whom Hilgard was now to be assistant, and whom he was not slow to discover incompetent on all scores, to a degree bordering so closely upon charlatanism that the selection condemns the appointing powers. But Harper showed himself an adept in political manipulation;

even after being forced from his professorship in 1856 for gross incapacity, he was still able to challenge the university authorities and to retain, through action by the legislature, the position of State Geologist as an independent office. Having rendered unintended service to the State in promoting this desirable separation, however, his nullity soon became too notorious. He held his place scarcely a year and disappeared from the scene with 1857.

As aide to a chief of that type, Hilgard was, of course, solely responsible for whatever the survey actually accomplished. He was able to take up field-work in the fall of 1855. He elaborated his notes during the winter 1855-56 and resumed explorations the following summer. We can imagine what internal chafing the talented young assistant underwent within the limitations imposed by such false conditions, and how they might have dulled a less deep-seated scientific purpose or warped a weaker rectitude to disloyalty. Yet, while making steady professional progress in the survey and gaining insight by experience in other channels, his temper of mind remained entirely unspoiled. Though, for example, the president of the board of trustees, Jacob Thompson, prompt to recognize this new driving-force, began already in 1855 to take intimate counsel with Hilgard about the report due from Harper for presentation to the legislature that winter. Indeed, under an appointment as private secretary that really included a general advisory relation about the survey Dr. Hilgard accompanied Thompson to the legislative session, and incidentally witnessed his defeat by Jefferson Davis in a campaign for the United States senatorship that is now historically memorable.

At the close of the season for field-work in 1856, it seemed profitable that Hilgard should confer personally with Tuomey, the State Geologist of Alabama, in the interest of establishing due co-operation; more especially also in order to obtain expert backing for the purchase of a set of reference books sorely needed in identifying collected material. This was intended to combat openly Harper's procedure, who would persist in ignoring previous discoveries and data, going to the absurdly unscientific extent of proposing a new name independently for each species of fossil that Hilgard might collect.

What was learned through this personal contact with Tuomey supported the teachings of current experience about giving full prominence to the agricultural bearings of the survey in Mississippi, and strengthened the growth of that policy whose seeds had been sown by the first suggestions of Dr. Owen; that main idea to which Hilgard adhered consistently always, and which he had adopted already when first confirmed as head of the independent survey. This was early in 1858, after a previous short tenure under the university as acting director, immediately following Harper's downfall.

Hilgard had then been summoned from Washington, whither he had retired in 1857, taking this step in avoidance of working conditions become impossible under the new-fledged State Geologist. The interim had been employed fruitfully in the chemical laboratory of the Smithsonian Institution, where Professor Henry offered a warm welcome. Here Hilgard carried to completion two investigations: the first concerned itself with "The Assay of Chromium by Blowpipe Processes," the method being based upon fusion of any chromium ore with alkaline carbonates, followed by a second fusion with acid potassium sulphate, which can be caused to yield anhydrous and insoluble chrome alum—a unique reaction. The discovery was announced at once to the American Association for the Advancement of Science, and was incorporated into the English edition of Plattner's Blowpipe Methods. The other research attempted to exploit the glass-like texture of metastyrol for optical constructions; but disappointment was met because an extending network of minute fissures finally marred the polished surfaces.

The resumption of work at Oxford marks a phase of advancement. As director of the Geological Survey, Dr. Hilgard was taking already, at the age of twenty-five, a conceded place in his State community, and he had set his foot on the road to a national prominence in his chosen field of geology, that he increased and carried with him when he turned with growing attraction toward that other specialized activity by which his matured powers were to attain widest reputation. Through the years next following, while preserving prudently every advantage of close touch with the university and its resources, he was engaged strenuously in discharging his obligation to build up the survey on a sure foundation of work in the field and the laboratory. An exponent always of the movement to broaden its agricultural aspects in the light of an assured belief, he endeavored wisely to educate public opinion into supporting him intelligently; for the renewed enterprise could not suddenly throw off the ill-repute caused by Harper's failure, while the antidote in Hilgard's effective scientific methods was not at first popularly grasped. The survey, in fact, did not escape the vicissitudes that commonly beset like attempts; so to give it a firmer foothold was one main aim of the new director's first report, as well as to break the force in advance of some political retaliation that was learned to be impending in the legislature of 1858-59.

In a common-sense statement, accessible to the plain understanding, that report, by the intention of its author: "Discussed the need and advantages of a thorough geological and agricultural survey of the State; recited the causes of the slow progress and failure to satisfy the public, chief among which were inadequate appropriations and the rank incompetency of the late incumbent. Also it gave examples of what had been done in other States, and closed with a recommendation to restore the geological assistantship, in connection with a more reasonably adequate appropriation." In spite of these prophylactic measures, however, an investigating committee went so far as to report a bill "to abolish the geological and agricultural survey of the State," which was suppressed only after vigorous conferences between the chairman and the aggressive director, and the bold challenge of the latter to acquiesce in dismissal for good cause proved, provided that the survey might thus be preserved from interruption. This one symptomatic incident illustrates picturesquely how unconquerable fighting spirit was needed, beside scientific attainment, before momentum was imparted where highest public interest demanded it. The first success in counter-offensive was driven home with a second report at the legislative session of 1859-60, after the open season had been utilized in the field as usual. The outcome was now more favorable; Hilgard's account reads: "The bill reported by the committee and afterwards passed with little difficulty by the legislature made no radical changes in the previous act defining the objects of the survey, provided for the appointment of an assistant geologist, and enlarged the limits of the annual expenses."

The document thus persuasive of the legislature was preliminary only. The completed report, in which more scientific tone prevailed, could not be printed in full until the necessary funds had been voted. It was in fact held back until 1866 from effective publication, and even after this delay, from the circulation that it merited, by circumstances growing out of the Civil War, though the printed sheets of it were turned over in November, 1860. We find it remarkable in its early perception of a true perspective for these matters which no grounds appeared later to modify, as is evidenced by the authentic summary from which we extract the following:

"In this report I undertook to separate as far as possible the purely scientific part from that bearing directly upon practical points, in order to render the latter as accessible to unscientific readers as the nature of the case permitted; while at the same time giving scientific discussion full swing in its proper place. The volume is thus divided nearly evenly between a 'geological' and an 'agricultural' portion; the former giving under the special heading of 'useful materials' the technically important features of each formation, after its geological characters had been discussed. In the agricultural portion it seemed needful at the time to give by way of introduction a brief discussion of the principles of agricultural chemistry, then but little understood; and to explain their application to the agricultural practice of the State. In the descriptive portion of the agricultural report the State is divided into regions characterized by more or less uniformity of soil and surface features; and each is considered in detail, special attention being given to the nature of the soils as shown by their vegetation and analysis. In the latter respect I departed pointedly from the then prevailing opinions, by which soil analysis was held to be practically useless. My exploration of the State had shown me such intimate connection between the natural vegetation and the varying chemical nature of the underlying strata that have contributed to soil formation, as greatly to encourage the belief that definite results could be obtained from a considerable number of analyses, of soils classified with respect both to their origin and to their natural vegetation, and a comparison of these data with the results of cultivation. Thus it would become possible, after all, to do what Liebig originally expected could be done, viz.: predict measurably the behavior of soils in cultivation from their chemical composition. The lights then obtained encouraged me to persevere in the same line of investigation, in the face of much adverse criticism, when wider opportunities presented themselves afterwards. By the aid of these I think I may fairly claim that the right of soil analysis to be considered as an essential and often decisive factor in the *a priori* estimation of the cultural value of virgin soils has been well established alongside of the limitations imposed by physical and climatic conditions, and by previous intervention of culture. Even apart from any special investigations of soil composition, the right of the agricultural interests to an intelligent and intelligible description of the surface features of a region, given with respect to its agricultural capabilities, can hardly be denied. Dr. Owen, among the older American geologists, was the one who kept in view most steadily the agricultural interests. And while our personal intercourse predisposed me to follow his example, my further experience has only served to strengthen my conviction in that respect. No troublesome agitation occurred to obstruct the survey in Mississippi after the publication of my report in 1860."

Having succeeded in putting the survey upon a more stable and assured footing, Dr. Hilgard might well assume that he had earned a vacation; and accordingly he made arrangements to spend some four months in Europe during the second half of 1860. This took on the color of a wedding journey, for he brought his wife back with him to Oxford in November; almost on the eve of the Civil War that was to convulse the next five or six years, dislocating normal activities of peaceful progress like the prosecution of the survey. Under the terrible stress brought to bear within the State by the impending conflict, it would have been natural to await complete extinction of the appropriation; but instead the legislature at a called session in August, 1861, only passed an act: "Suspending the appropriation until the close of the war and for twelve months thereafter, except that the sum of twelve hundred and fifty dollars per annum shall be applied to the salary of the State Geologist, and the purchase of such chemicals as may be necessary to carry on the analysis of soils, minerals and mineral waters, and enable him to preserve the apparatus, analyses and other property of the State connected with said survey." In the form given to this action we can read a newly-enlightened confidence in the director and his work. This appropriation, moreover, was actually maintained through the entire struggle of the Confederacy, and so far as the fortunes of war permitted, the chemical work was continued, and at times also the field-work.

The scarcity of salt suggested utilizing the saline waters common in southern Mississippi, and the pressing need of nitrates led to exploring some promising limestone caves. Hilgard made report on both these subjects to Governor Pettus in June, 1862. Those commissions for the public welfare barred enlistment in army service when the university faculty was disbanded soon after the beginning of active hostilities in Tennessee. Unless Hilgard's detail be so considered, to install calcium lights on the bluffs above Vicksburg and illuminate as targets any Federal gunboats that might attempt to run the gauntlet of the shore-batteries by night. Here, to be sure, delays in obtaining materials and in construction frustrated execution of the plan at the final passage of the fleet, which was not hindered by such searchlights. During most of the wartime, indeed, Dr. Hilgard remained at Oxford, having been officially placed in charge of the university property for its preservation. Here his duties were no sinecure, because he was located in a belt of desolation between opposed armies that swept back and forth over it. The collections of the survey had more than one narrow escape from destruction when the university buildings were later occupied hastily as hospitals, but they came off finally without material injury. On many occasions, too, the "State Geologist" was kept very busy aiding in the care of hospital patients or in preparing medical supplies for them in his laboratory. But again there fell quiet intervals, and then we see him turning to some investigation. In such a period, for instance, he invented a turpentine-lamp for domestic use, kerosene being unprocurable; and, incidentally to this, he determined the conditions under which the distillate from crude oil of turpentine that has been digested with sulphuric acid contains a maximum of the desirable terebene. He was baffled, though, by an unremovable impurity that incrusted his lampwicks beyond what was practically allowed.

The interruptions of the war-years ceased at length, and regular effort to advance the survey was resumed. This may be dated in July, 1866, when Dr. George Little was appointed Assistant Geologist. He took the field shortly thereafter for an exploration of the loess region from Rodney, Mississippi, to its farthest point in Louisiana. The general results of this expedition were summarized for the Smithsonian Contributions, but the times were still disturbed and no detailed report was ever made. In fact, under the *régime* then imposed upon the State, the insecurity and the difficulties then besetting the office of State Geologist were such that in October, 1866, Dr. Hilgard was induced to accept a permanent transfer to the chair of chemistry in the university. Upon his recommendation, Little was then appointed State Geologist; but in 1870 he in turn exchanged this charge for a professorship, and Hilgard became again director; but unsalaried and relieved from any obligation to carry on field-work personally. This step seemed advisable as the one means of preventing the survey either from being abolished or from falling into wrong hands; being evidently dictated by unflagging interest in the Geological Survey sustained amid the claims of the chair of chemistry. That responsible guidance and supervision of the work entrusted to successive assistants continued until the autumn of 1872, when the survey's appropriation was suddenly withheld under an arbitrary ruling of the State Auditor, and its activities were in consequence peremptorily suspended. We learn that this perverse obstruction was endured with acquiescence until 1906!

While discharging his duties as professor of chemistry Hilgard kept mind and hand constantly upon the geological survey during his remaining years of service at the University of Mississippi; for this we find clear testimony in a series of published papers belonging to the period 1866-73. These deal at first with geology or its direct bearings upon agriculture; but later include discussion of agricultural education also, as that grew to be a burning question. Some changing orientation of central purpose is reflected probably in a change of his title to "Professor of Experimental and Agricultural Chemistry" that falls in 1871 and could be taken to indicate an incipient shift toward developing that field in which he was to become an authority of first rank. But all this came after he had gained distinction as a geologist; and we shall adapt our account best to that view of the sequences if we round out the recital of what Hilgard accomplished in developing the geology of Mississippi and Louisiana, before proceeding past the transition to his later occupation with other problems.

Overcoming various hindrances whose nature and source can be inferred in the light of preceding pages, Hilgard had made a good showing of results for the years before the war. Orienting himself by a rapid reconnaissance in 1855, the expedition of the next year enabled him to determine the character, stratigraphical relations, and limits of the carboniferous, cretaceous, tertiary, and quaternary beds in the northeastern part of Mississippi. That season he located the "Ripley Group" and made collections from it; also he investigated closely the features and geological relations of the "Orange Sand," and characterized it definitely as a quaternary deposit. The atmosphere being cleared after the removal of Harper, serious tasks could be continued in 1858. A full section across the tertiary area from north to south was verified; the fossiliferous localities of the "Jackson" and the "Vicksburg" stages were subjected to detailed examination; the infra-position of the latter relatively to the "Grand Gulf" group was put beyond question. The campaign of 1859 was devoted mainly to detailing previous outlines, and its net outcome is declared to have confirmed their conclusions as well as completed them, so bearing witness of sound preliminary judgment. The report of date 1860, of whose fateful postponement we have spoken above, contains summary and analysis of all these particulars. Its author's modest candor did not stand in the way of claiming for it in after years that "In a revised edition the report would, without additional field-work, still form a pretty complete account of the geological and agricultural features of the States; especially through its mapping and study of the cretaceous and tertiary formations."

The survey in Mississippi had in view primarily to benefit that one State and to develop its resources, of course. Yet Hilgard never overlooked the gain for surveys in neighboring States through conference and co-operation, as his meetings sought with Owen and Tuomey could testify. Such supports became more advantageous; or we may say they were seen to be necessary; where it was plain that a certain geological unity crossed geographical boundaries as in the case of Louisiana and Mississippi. Therefore, we must regard it as fortunate that circumstances arose to place in Hilgard's hands the possibility of connected treatment for geological problems common to these two States, that led to the recognition of what he was the first to term the "Mississippi Embayment," and to study of the river in its last stretch to the Gulf.

The initial move toward that end was made in 1866, when General Humphreys, chief of the United States engineers, proposed that Professor Hilgard should investigate the character and the geological age of specimens taken from a well-boring at New Orleans in 1856. This proposal, which was accepted, followed a suggestion from Sir Charles Lyell that the shells collected while boring that artesian well should be compared by some competent authority with those of the cretaceous and tertiary formations on the one hand, and on the other with those now living in the waters of the Gulf of Mexico. It was anticipated that this examination should settle the question whether the "Mississippi River is flowing through the delta region in a channel belonging to a geological epoch antecedent to the present" (Humphreys). Here, again, the consequences of war interfered through damage due to exposure in the suite of specimens available at the New Orleans Academy of Sciences. For that reason mainly the final conclusion could not be rendered until 1870, to be published in the Report of the Mississippi River Commission of that year. Hilgard's verdict was decisive, in that it established with regard to forty species of shells examined, that four only were not known to be now living in the waters of the Gulf.

A second direct contact with the geology of Louisiana followed upon a proposition coming from Professor Henry in Washington that Hilgard should inquire into the age and origin of the rocksalt deposit in Petit Anse Island which had been a source of supply for the Confederates during the war. This came in 1867, and under the auspices of the Smithsonian Institution; it would involve necessarily, as Hilgard saw at once, a general study of geological structure on the Gulf Coast from the mouths of the Mississippi westward, so far as this was not yet known, and he welcomed the opportunity. In the prosecution of this inquiry the local Academy joined with active interest when New Orleans was reached, after descending the river from Vicksburg with stops for investigation at various points, to secure data for clearing up geological questions.

It was while continuing this journey down the river that Hilgard's attention was first specially directed to the study of the so-called "Mudlumps" and their origin. They were formidable obstructions to the navigation of the channels through the delta; proving unmanageable by powerful dredges, continually replacing themselves or breaking out in new localities. These "Evil geniuses of the passes" had it is true been observed by Lyell as early as 1849; but his explanation of the working causes by which they rise was incomplete, and the geologists coming after him had taken little notice or none of the peculiar phenomenon. It was reserved for Hilgard to conjecture from detailed examination of them upon the spot how the occurrence of mudlumps is correlated with the existence of an impervious substratum of clay extending seaward, on which the bar deposit can dam the mud-layer precipitated from the turbid river on meeting the sea. Extruded by hydrostatic pressure in the channels and marshes above the bar, that semifluid mud constitutes mudlumps wherever local conditions are favorable. This solution was sustained fully by physical, microscopic, and chemical analyses of the oozing mud, and by exhaustive discussion of the prevailing factors that caused mudlumps to be largest and most frequent. The details of the definitive report are to be found in the *American Journal of Science* for 1871.

The immediate purpose of the expedition in 1867 carried it, after the river mouths had been passed, to the chain of "Five Islands" of which Petit Anse is one. Thomassy had once traversed this ground, describing the islands as due to "Hydrothermal or volcanic forces." This was vague enough to leave the door open for an origin analogous or not to that of the mudlump-cones. On the present occasion the closer examination was confined to Petit Anse and its two neighbors, observation having shown that the five islands were not essentially differentiated. With habitual scientific caution Hilgard pronounced the local results inconclusive until interpreted through their wider connections with the geological formations of Louisiana and Mississippi. This attitude seems to have stimulated provision for a general reconnaissance of the former State, for which funds were supplied through the efforts of the New Orleans Academy co-operating with the State Board of Immigration; a plain instance where enthusiasm and tactful persuasion succeeded in yoking other forces toward pursuit of good aims. In the early summer of 1868 Hilgard and two companions were thus enabled to employ some six weeks on a line extending perhaps six hundred miles northward from New Orleans. Though the exploration was perforce conducted at a rapid pace, it yielded data for determining the salient features of the geology and of the surface conformation; valuable specimens to the number of two hundred and fifty were collected, and a few months later the first geological sketch-map of Louisiana could be submitted to the meeting of the American Association at Chicago. The general accuracy of that map stood well the test of subsequent researches that have amplified it and supplied missing detail; for instance, the State geological surveys under Hopkins and Lockett. The relatively fruitful and permanent outcome of so brief and hurried reconnaissance was due largely to its leader's happy inference that the event so fairly justified, of important geological similarities between Louisiana and Mississippi which allowed some conclusions from the study of one State to be extended to the other. Especially the legend previously current was cancelled, that the "greater part of Louisiana is alluvial," on proof that much of the prairie country is underlaid by what Hilgard had in the preceding year first named the "Port Hudson formation." This was found replaced farther north by the marine eocene in the hilly country, and at the Five Islands by formations of cretaceous age, of which their bluffs show the southern outcrop. The careful study naturally requisite for the elaboration of all such important conclusions that were to revise older ideas was carried on through the next four years. Its results, including analyses of rock and soil, being then published by the New Orleans Academy in 1873. And finally Hilgard was able to co-ordinate this reconnaissance with other studies in Mississippi and reach safe decision about Petit Anse; the problem that had shown the need of comprehensive view and set on foot the movement to obtain it. That full discussion was published as No. 248 of the Smithsonian Contributions in 1872.

The solid achievements in geology that are here condensed into briefest account had strongly interested experts like Dana, who counseled wider publicity for the parts embodied in that report of 1860 which the war had shelved temporarily. Accordingly Hilgard published in 1866-67 several articles in the *American Journal of Science* on the geology of Mississippi and the Southwest generally whose matter, as he tells us, excerpted and expanded the earlier substance of the report. Here belong, for example, the papers on "The Quaternary Formations of Mississippi;" and on "The Tertiary Formations of the Southwest." But we begin now to find a parallel line of publication on subjects connected with agriculture and agricultural education to which he was giving increased attention. The first important title there belongs to 1870; it reads "On the Maintenance of Fertility in Soils." So it may be held significant of a new trend that after presenting at the meeting of the American Association in 1871 a discussion of "The Geological History of the Gulf of Mexico," Hilgard went on to Chicago as delegate from his university to the first convention of Agricultural Colleges established under the Morrill Act of 1862, that Mississippi was intending to avail itself of. It is worth remarking that Hilgard and Gilman met for the first time at this convention; perhaps a fateful conjunction for the former. Gilman was then in the service of Yale, but his keen insight for men's adaptations could not have overlooked Hilgard's quality; and a tenacious memory would hold the impression for use in California a few years later.

With agricultural education as one chief topic before the convention, the so-called "Michigan plan" was advocated by the representative of that university, under which the students' time was devoted in large part to manual labor on a model farm in order to "Maintain the habit of work and prevent them from being educated away from farming pursuits by too much indulgence in academic studies." But Hilgard's independence of judgment asserted itself; both by opposing that view in the convention, and by the poise of the report to his own trustees. It is encouraging to note that such moderation earned respect from Michigan as well as from Yale—subsequent events were to prove this. How clearly that early report held the balance between exaggerating tendencies which Hilgard thereafter maintained steadily is visible in his own summary which runs: "I concluded essentially that neither of the two extreme plans should be adopted, typified respectively by the farm-school idea followed in Michigan and Pennsylvania and by the Sheffield Scientific School at Yale. The chief object of the State colleges should be to educate teachers and leaders of progress in agriculture; uninstructive labor should not be enforced upon the students save to the extent of familiarizing them duly with the actual performance of farm work." The trustees at Oxford were wise enough to begin by following these suggestions; and one part of their action was to select the editor of an agricultural journal to be "Professor of Practical Agriculture," Hilgard's title being changed to "Professor of Experimental and Agricultural Chemistry." The new arrangement had a transient success in gathering a considerable group of students; but they dwindled after a fashion that repeated experience was to make familiar, and nearly disappeared by the close of the session. In another particular, too, that first venture was ominously prophetic; for at the succeeding session of the legislature these results were made a pretext for launching an attack upon the appropriation. With the sequel, also to be repeated in other States, in a proposition to separate the Agricultural College from the university. Hence, by November, 1872, we find Hilgard in a defensive campaign against this agitation; delivering addresses on such subjects as "Progressive Agriculture and Industrial Education." But the difficulties of the position thickened as time went on, instead of yielding; so it is without surprise that we finally find him accepting in 1873 a call to Ann Arbor as "Professor of Geology and Natural History." This was a repetition, with conditions that improved it to the level of acceptance, of proposals made in 1871 and again in 1872 that had been declined. In August, 1873, the family removed to their new surroundings.

Meanwhile Hilgard continued steadily productive and increased solidly his professional reputation. The article on "Soil Analyses and their Utility" appeared in 1872, whose tone of rather drastic criticism upon Johnson, of Yale, was provoked by some utterances of the latter about the same matter. He was entrenched already behind his meritorious books: "How Crops Grow," "How Crops Feed", while Hilgard was at that period, in his own overmodest estimate, "An unknown writer who had not yet won his spurs." So one rejoices to learn how temperately Johnson made rejoinder; and how a pleasant friendship of the two men, continued by correspondence and at the meetings of the American Association, grew out of the first controversy's warmth, and bore convincing testimony to scientific candor on both sides.

Hilgard then followed that first paper quickly with two others on the physical analysis of soils. And out of his thought dwelling persistently on methods of executing such analyses was evolved his "Soil elutriator" that has since come into such extended use as a standard instrument for its purpose, on account of its perfected improvement in consistency of results. It was a part of the investigation that led to devising Hilgard's form of elutriator to study anew the diffusion of clay in water, with the conditions of its flocculation and precipitation. Here he discovered independently the main conclusions reached by Schlösing somewhat earlier, but whose published form in the *Comptes Rendus* had not arrived at Oxford. The dates of Hilgard's papers on this subject, as they appeared in the *American Journal of Science,* were 1873 and 1874.

The life at the University of Michigan opened under favorable auspices. President Angell was noted for promoting cordial relations among his colleagues, and between them and groups of their prominent town neighbors. He was a praiseworthy leader, too, in fostering simplicity of living and the types of intimacy that are apt to accompany it; the elaborateness and the scale of expenditure were still absent that have later brought an attendant sophistication into many university communities. Welcomed in this circle, Hilgard was not made to feel either any offensive reminder that he came to Ann Arbor direct from a Southern State. And then, as regarded his title, against whose over-comprehensiveness for a single chair he had not failed to file remonstrance in accepting it, the apprehension had outrun reality. Assistants were duly provided for botany and zoology, relieving Hilgard in those directions of all but organizing supervision, and leaving reasonable freedom to devote himself where his more vital interests in geology and mineralogy called him. Yet, those two years at Michigan were in sum rather a period of marking time, though strewn abundantly with recognition and other pleasant experiences; it seems clear that Hilgard looked upon them in retrospect more as an intermezzo between the two strenuous campaigns of his life, in Mississippi and in California. His classes were large and appreciative; but he found himself fretting noticeably at being debarred from opportunity worthy of his powers for active investigation. It was no satisfactory outlet to inculcate respect for university furniture; nor to lend vigorous support in toning up student discipline; though there again his capacity for leadership soon became apparent. Neither was it a complete consolation to be located once more within easy access to the older civilizations which had been sensitively missed at Oxford, except what correspondence could do. Now frequent personal contact with notable men became possible, and it is certain that Hilgard relished keenly that feature of his new position.

But in some larger things his initiative met with mediocre success. A profitable suggestion that he should make his experience available to the State geological survey and care for the agricultural aspects of it that were being neglected entirely, was thwarted by a refractory and unsympathetic State Geologist, though advocated warmly by President Angell. Hilgard's natural instinct to infuse a larger quantum of scientific ideas into agriculture was baffled, besides, by the segregation of the Agricultural College into a separate institution at Lansing and the unshakable dominance there of so-called "practical tendencies." He, indeed, attacked that heresy early and with his accustomed vigor at a convention in Kalamazoo, so that he described himself as: "Reading the delegates the riot act about their supineness in advancing rational agriculture in their State; and holding up before them his Mississippi gospel that since world-competition has compelled the use of brains, besides brawn, in farming, it must become indispensable for agricultural colleges to bring forth leaders." But though he brought matters to the pass of discussion in popular meetings, he failed to make sufficient headway against the settled adhesion to this "Michigan plan." After combating at every opportunity that "Low view of their functions," he was obliged to "leave it to the twentieth century to bring about any competent realization of the needed change in policy." Satisfied that the "Farm-school was a plain violation of both the letter and the spirit of the Morrill Act, which calls for instruction in the *sciences related to agriculture* and the mechanic arts," he proceeds, "I once wrote to Mr. Morrill asking for his own interpretation of the act. His reply was that its language was plain enough, but that he wished to allow liberty to each State to adapt the college to its needs. That these needs were not farm-schools only was soon made evident by the establishment of academic departments in all the colleges that at first adopted the Michigan plan; so the event has justified my contention."

Obstructed then by these hindrances to his first choices of activity, Hilgard sought a partial substitute in constructive writing. For his own classes a better adapted textbook on geology; and at Dana's solicitation an extended review of Mallet's frictional theory of vulcanicity that excited general attention and discussion, beside calling forth an appreciative letter from Mallet himself. But much writing seemed incompatible with the condition of his eyes, which began to trouble him so seriously that an operation to correct strabismus was proposed. Not assenting to this, he was confirmed in that judgment by his brother, whom he consulted in New York, and who recommended again, as in the early years abroad, rather an open-air life to strengthen the nerves. But that idea could not be entertained under the circumstances. Hilgard then used his chance to attend the session of the American Association at Hartford, and thus casually renewed his acquaintance with Gilman who was now, in 1874, president of the University of California. It transpired that he was charged to select a suitable professor of agriculture, the chair being vacant by a dismissal for political tactics. The meeting must have seemed providential to Gilman; without delay he offered the professorship to Hilgard, and met the natural objection to taking so sudden a leap in the dark resourcefully by a compromise proposal. This was to the effect that Hilgard should return with him to California, obtaining a leave of absence from Ann Arbor, "To see and be seen, and to deliver a short course of lectures on agriculture at the University of California." As might have been anticipated, President Angell was up in arms against the plan: "Warning strenuously against going to such a hornet's nest as the university at Berkeley was reputed to be." Nevertheless, Hilgard telegraphed his acceptance of the temporary engagement to Gilman, whom he was able to join at Chicago; so the two men made the rest of the long journey together, which had not yet lost its charm of being a novelty and an adventure. The breadth of the desert belt beyond which the western coast lies has not yet ceased to be deterrent; it speaks plainly of an obscuring isolation that professional ambition will always shun. In those days the separation was felt strongly, sufficing to halt all but the pioneer's enterprise, or a firm enough faith in one's power to make oneself heard from California in the larger world, whose appreciation is success. The apostolic motive had been quick within Hilgard from the beginning of his onset in Mississippi, when he was obliged to find sustenance mainly through internal conviction. But he could enter California now fortified in addition with an authority conceded to recognized accomplishment. Still, even so, it would have been foolhardy to commit his family fortunes to this hazard without first feeling out the terrain by something like the scouting expedition in which he was here engaged.

In the long course of that journey we see Hilgard exposed to his companion's tried gift of persuasion, directed toward fixing him in secure alliance for that severe campaign which Gilman knew to be impending, and in which the aid would be invaluable of a professor who had served his novitiate already in dealing with legislatures and with reluctant or suspicious farmers. Such a trained instrumentality fitted Gilman's wise tactics to protect the college of agriculture against being dwarfed into a trade-school or derogating otherwise from its function of genuinely capable leadership, by placing a man of acknowledged scientific rank in charge of its development. There is of irony more than a touch in the known sequel; it was Gilman who fell away from the alliance before it could be made really operative. His transfer to Baltimore in 1875 left Hilgard to contend with his difficulties single-handed, bare of that support which alone had made the position look acceptable.

In that preliminary season of 1874, however, everything seemed of good promise on all sides. During six weeks Hilgard delivered an effective course of lectures at the university on "The Origin, Properties and Functions of Soils," to an audience of perhaps twenty-five, comparatively large for the conditions and mostly graduate students, the scope of whose purposes made them available. Though to some the subject-matter might sound a little remote, their unflagging interest was held by this contact with a "prime-mover" of the scientific world, fed from the same sources as Bunsen, but no mere echo of his teacher. The lectures appeared in published form shortly and affected noticeably a larger public; the leaven began at once to work, for we learn: "They served as a basis of conciliation between the patrons of husbandry and the regents of the University." Nevertheless, after even this measure of prompt success, Hilgard assures us that he went back to Ann Arbor: "Not without a lingering thought of returning to California, but also without encouraging in any definite way the reiterated suggestions of Dr. Gilman to that effect." It appears to have needed the hard winter 1874-75 to turn the scale, by causing reflection whether it would be advisable to remain in a climate that subjected the whole family to such vicissitudes frequently, accustomed as they were to the mild seasons of Mississippi. February brought also a rather serious illness to Hilgard, followed by a slow convalescence and the medical dictum that winters in Ann Arbor were too severe. Upon this situation fell the notification of formal election to the chair of agriculture at Berkeley, to date from October, 1874, with its salary. But still he wavered. "After some hesitation, I wrote a letter of acceptance, amid the protests of my friends in Ann Arbor, especially of Dr. Angell, who said that if I *would* go he would give me chance to repent by holding the chair vacant for six months." Here is the pendant picture of arrival: "When, after an uneventful overland voyage, we landed in Oakland, I found to my intense disappointment that Dr. Gilman was on the point of leaving the University of California for the presidency of Johns Hopkins University, at Baltimore. Had I known this, I might never have left Ann Arbor, and I thought for a moment of turning round immediately. But Dr. Gilman protested that I ought at least to try and study the situation; and, although he was leaving, I would have the strong help of the Board of Regents, and a new and fruitful field of investigation instead of the mere routine of teaching at Ann Arbor. And he gave me as his farewell a numerously attended reception at which he introduced me to a large number of influential people with warm recommendations for aid in my task. So I did not return to Ann Arbor, but resolved to fight it out as I had done in Mississippi before. The fight turned out to be quite as hard as anticipated, for a number of years. But I won in the end; and the climatic advantages proved for myself and my family an ample offset in the prolongation of life and health to the social pleasantness we had relinquished in making the change." Perhaps this account is not wholly free from satirical intent. But penning it in 1912, Hilgard could afford to speak with the generous security of a man who had habitually faced heavy odds and overcome them; and seeing his term of service to the country at large lengthened, as in human estimate we must believe, he learned to acquiesce unresentfully in the shuffle by which he figured as Gilman's important legacy to California. There is a heavy debit in the balance-sheet, however, wherever a talent like Hilgard's is applied to a second burden of pioneering and in ripened development is confronted with those wasteful hindrances which accompany foundation-laying in newer communities. Unless this is realized properly, his record in California—massive performance though it is—will appear discounted as compared with what those thirty years might have represented in the same tireless continuance of activities already begun. Without the consideration that it qualifies the medium and not the man, we might see some pathetic shadow in this memorial comment, across its else unstinted praise: "Gauged by the time and opportunity, Hilgard's will remain a great work. The results of his labors are in the warp of California's first half-century of intellectual and industrial life, and upon such enduring work as he achieved will be spread the splendid fabric of the coming advancement and development of our State. He did his best work for agriculture in the university by making the greatness of its future secure."

It is enlightening preparation for tracing the sequel, to look back deliberately upon some elements in the combination that Hilgard was asked to shape for the good of California, and that meant for him, through a long series of years to come, deadweight to lift or perverse views to correct. Within the university, the "strong help from the Regents," in the words of Gilman's assurance, was not yet in evidence. Indeed, it was the contemporary judgment about that Board that Hilgard's promptly aggressive campaign was disquieting to them; their counsel of opportunism was rather to await favoring winds placidly. Neither was this policy disturbed by any action of the new president, himself a busy scholar and sympathetic to Hilgard's scientific attitude, but prone to shrink from any array of contending forces. The eyes of the faculty were opened to the danger for the university as an institution of the strong movement on foot to divorce its College of Agriculture. In warding off that ruinous separation there was much active co-operation from his colleagues. Otherwise Hilgard was in a position to give more than he received from them, by taking a leading part, through the weight of his own broad culture that made him charitable and tolerant for other specialists, in the general effort then engaging the attention of scientific professors to gain due foothold in the curriculum. But we cannot be sure that his tolerance was repaid in full, when it came to the question of supporting loyally his wise view of the fundamentals in agricultural education. There he wielded a free lance for many years before he could carry conviction among his associates. The attendance of agricultural students remained near zero in those first years; so that a man less courageous in cherishing ideals might easily have had recourse to some new recipe more highly flavored to attract a constituency; but Hilgard elected to stand firm and bide his time. Thus it came that he took upon himself the teaching of other sciences not then provided for in the faculty, notably of botany and mineralogy; a widening of actual scope in his chair beyond its nominal obligations that contrasts with the supplementary relief from multifarious duties that had been contrived for him at Michigan.

Outside the university, Hilgard found great nakedness of serviceable connections until he built them up. No State Survey was in existence, at first or afterwards, to stimulate into co-ordinated action—a single effort in the direction of having one organized was so hopelessly rebuffed, the situation being prejudiced by previous unfortunate relations with a United States Geological Survey in the State, that even Hilgard's fighting spirit must judge further attempt futile. In this respect again the comparison was not favorable to California; with either Mississippi or Michigan as the other term. It may sound a hard saying, though it is scarcely an untrue one, that some provincial atmosphere was still clinging about California, one peculiarity of whose history turns at several points upon the reactions of a community that was less far advanced to quickening influences exerted by the College of California and its successor, the State University.

The first two or three years of Hilgard's new official relations were the reverse of encouraging, moreover, on account of a newspaper campaign against the Regents which did not fail to include attacks upon a professor who had replaced a dismissed popular favorite. So in unavoidable self-defense, he was compelled to divert a good share of valuable energy into a series of articles in local journals, where he argued once more the case for a college of agriculture, founded on progressive scientific investigation of conditions and on improved adaptation of methods, in addition to transmitting a standard tradition about practice. Nor could he in prudence rest satisfied with printed presentation; so he did not delay beginning systematic appearance at farmers' meetings, in order to dissolve opposition and convert adverse opinion. Amid such surroundings we find this favored disciple of Bunsen and geologist of national repute brilliantly successful by his conciliatory tone and tactful utterance, on the testimony of an expert eye-witness in 1876: "The room was not large, and was crowded with men of some prominence in farming and hostile to the university because they really believed that the College of Agriculture ought to be snatched from ruinous association with a so-called 'classical institution.' It was a stormy assembly, but when there came a lull the chairman asked Hilgard to speak. He rose alertly, showing them a slim, graceful figure and a scholarly face illumined with an eagerness, cordiality and brightness of expression which seemed to say to them: I never was in such a delightful place before in my life. When he began to speak in a low, conversational voice, every man was at attention. He was saying that no one could do much for farming unless he had personal knowledge and support of farmers; that he had come to California to try, with their aid, to know California from the rocks to the sky, and proposed to use all that he had learned in other lands merely as a help to begin to know California, which he had already perceived to be different from any other land in which he had lived and worked. On his father's farm in Illinois he learned that soil differed when it came from different rocks, when it was moved about in different ways and when other things were mixed with it, and since boyhood he had been studying the rocks, the soils, the plants in the hope of matching them up, to get the best crops and the most money in farming—and then followed a charming half-hour with soil formation and movement, tillage and fertilization, without a scientific term, without reference to a chemical formula—all straight farming talk about soils and plants. Finally, he said he had come to find out how these things worked in California. He particularly wished to know whether California farmers had anything so hard to handle as the gumbo soil of the Mississippi Valley; and this was a master-stroke. Before he could regain his seat, questions were fired at him from all over the room, and he answered them readily and confidently, until the meeting closed after half an hour of such friendly and informal conference."

There were repetitions by the score of like sessions during the first few years, resulting in such approval of Hilgard's announced purposes that the segregation of the College of Agriculture from the rest of the university was barred in 1879 by an article in the State constitution of that date; the adoption of which article moreover was significantly moved by the State Master of the very organization in which opposition to Hilgard had centered. But while Hilgard put all necessary thought upon attaining these ends, and his vigor was able to secure a complete victory there, be sure he would rate them always as incidents of his main problem; let us say facts of its setting, duly to be dealt with like any other facts in a scientific procedure. Accordingly, he was continuously and absorbingly occupied, too, in those years with investigations covering the soils and the climates of California, both of which he declares to have presented many new features that demanded material modifications among ideas that he had considered settled by previous experiences. He proceeds in explanation: "Six months of clouds and flowers, six months of dust and sky, were to some extent familiar through my stay in Andalusia; and I saw here in California the very weeds that I had seen on the Mediterranean coast, evidently brought over unintentionally by the Franciscan missionaries in the agricultural seeds they imported. But I had paid little attention to soil conditions while in Spain, and was now confronted by the fact that not only native plants, but also eastern and European trees, remained green and bore fruit during six months of rainless hot summer. The investigation of this subject, and of the connected topic of 'alkali-soils,' have since become the chief study of my life, the direct inquiries into geological problems being relegated to the second place. I soon found that in order to teach my agricultural students usefully, I should have to become personally familiar with the soils and agriculture of California, as I was with those of Mississippi and the eastern States. Yet, there were no funds with which to travel; and without those means, how could I obtain a competent knowledge of the conditions under which I was to work?"

That question about ways and means, which is the bane of so many scientific undertakings, remained to hamper Hilgard perpetually; up to the time of his retirement he had hardly broken the habit of grudging financial provision for the needs in his rapidly expanded field of usefulness. It proved manageable only in part by rigid economy in outlay and by the slow process of educating authority to loosen purse-strings. Hilgard saw himself driven more than once to expedients that a less determined temperament would not have invented; especially by exploiting for the benefit of his adopted State the combinations of his local pursuits with larger commissions that his national standing brought him: the report on Cotton Production in the United States for the census of 1880; the inquiry into the asphaltum resources of Southern California for the Northern Pacific railroad; the field-work on the Pacific Coast for the Northern Transcontinental Survey. On the foundations for agricultural research laid down by a few such as Hilgard was, a vogue has been built for the application of scientific methods to farming, perhaps not without some popularizing concessions, to which is accorded freely even munificent expenditure. So the item bids fair to stand out curiously and mark the toilsome breaking of ground for this fair harvest, that in 1875 the first Agricultural Experiment Station in the country under the federal act was established in California; this priority being purchased at the moderate cost of two hundred and fifty dollars invested in maintenance. The initiative here was, of course, due to Hilgard, and the parsimony is some measure of the restrictions that were powerless to check his advance.

Hilgard was ready with a first published report in 1877. Beside chronicling the progress up to that date of his special labors in California, he used the occasion to summarize the principles by which he would be further guided. What his creed was, we have learned through contact with its application to Mississippi and to Michigan. It continued to shape his course in erecting the structure that will be his enduring monument. In California, without swerving in direction, his effort gained intensity by focusing upon agricultural development the energy and attention that had once been distributed over a more inclusive field of endeavor. From this time forward he directed unremittingly from the center at Berkeley the work belonging to the successive phases of California's agricultural growth, in flexible conformity to its changing emphasis upon viticulture and phylloxera; upon alkali-soils and irrigation; upon the various aspects of fruit-culture and grain-raising. It is inherent in the human nature of like relations to economic interests that they may involve selfish motives, the personalities of public controversy and similar sordid elements. Hilgard lived through trials of that character; himself not vitally perturbed by them, and never touched with any taint of their infection; persistently driving his saps to undermine every obstructive combination against the scientific welfare of the State as represented in its College of Agriculture. We could regard the culmination in this progress as attained in 1892; the year of a visit to Europe by way of vacation, from which Hilgard returned crowned with abundant and honoring recognition by his colleagues in other countries; were we not told by one who certainly stood close enough to judge the truth how: "After 1893, Hilgard applied himself for more than a decade with his customary vigor, insight and success, upon undertakings which were growing by leaps and bounds because he had started and directed them aright. His last years of administration were his best years; his position of leadership was unquestioned; his physical strength seemed greater than during some of his earlier periods; the demands for instruction and the opportunities for research were multiplied. He labored like one who was realizing the results he had long desired, and his heart was light as his time for greatest achievement had come." Retirement from office in 1905 arrived then as a breaking off with brain undimmed and capacity not yet on the ebb; a rather infrequent example, in its degree of preservation under advancing age of a vitality that we have seen threatened seriously at the threshold of manhood and first engagement upon heavy tasks.

It is fair to claim that the maturity of Hilgard's life was bound up with California. No adequately detailed impression of his tireless and varied productiveness throughout that space of over forty years must be looked for in a sketch like the present one. That can be gained only by a full analysis of his catalogued writings.* For the character of this biographical outline we must rest content with an excerpt to supplement our account, selecting where marked features or incidents lent a value known to agree with Hilgard's own estimate. On several counts first mention should probably be allotted to his share in the census of 1880. That was of national importance and range and its extended ramifications exhibit his fine quality in organizing and co-ordinating. It was an exemplar, too, of his capacity for ingenious legitimate strategy on a large scale, when he devised that particular backing of his State's welfare with the nation's interest, and delighted one shrewd observer, who is quotable: "As I look back upon it, it seems to me that Hilgard's strategic diversion of 1879 to 1883 was one of the brightest and most effective movements of his career. On the basis of his work in Mississippi he was requested to take full charge of the cotton investigation for the census of 1880. Hilgard seized what he recognized as exceptional opportunity to demonstrate his power. He selected assistants and set them at work studying cotton-producing conditions from the soil to the sky. He reviewed the subject as a whole and in divisions, studied each cotton State, and finally produced edifying and inviting text, illuminated with plates and maps, bristling with tables of analyses and with statistics of production. Every ounce of this report was made in California, and it is emblazoned with the insignia of the University of California, but it cost the State not a cent. California was presented as a cotton State and her natural conditions were so thoroughly studied and so ably set forth that a part of the report entitled 'The Physical Features of California' is cited to this day as authority. While his local patrons and employers were wondering how Hilgard could use $2,500, the United States gave him not less than $25,000 to spend in his cotton work—one wide-reaching result of which was that it made California famous."

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*A bibliography of these is made part of the publication: In Memoriam—Eugene Woldemar Hilgard (University of California Press, 1916). This is reproduced at the close of the present memoir.

The intimate history of this project would relate how only the idea in embryo was due to Director Walker, and how its possibilities were enlarged under suggestion. We should see Hilgard overcoming difficulties of personnel; writing at speed a pattern report on Louisiana for his subordinates to work by and editing into fair excellence their manuscripts, dovetailing the ill-matched joints into that final unity and comprehensiveness which are striking in the finished report. All this, too, at a time when he was under almost feverish pressure to complete his individual share, the exploration of the possible cotton-growing portions of California, chief among which was the Great Central Valley. He gives us a glimpse of what that implied: "In each of the three portions of the Valley, I observed a complete cross-section from the Coast Range to the Sierra foothills, also collecting representative soil samples for analysis. I was thus assured that in the great Valley at least upland cotton could be grown from end to end, with moderate irrigation in the southern portion. By utilizing all the sources of information then extant, in addition to my personal explorations, I was enabled to write a fairly complete and correct physiographic and agricultural description of the State north of the Tehachapi divide. But as no cotton had been grown south of that range, I needed some other plea for carrying the exploration into southern California, which was fortunately furnished, but from a private source. For, during the whole of my career in California," Hilgard affirms deliberately, "I have never been afforded by the State any official opportunity for collecting agricultural data, save by driblets on account of special cultures (notably viticulture), or of lectures to farmers, which could be utilized for such observations."

The "private source" here alluded to was an employment by those directing the Northern Pacific railroad's enterprises, to inquire into the asphaltum deposits of California, chiefly in Ventura County. The Northern Transcontinental Survey, financed by the same group, was also forcing the pace for Hilgard through the summer vacations of 1879-83, when he examined the mineral and agricultural resources in their congressional land grant. These expeditions took him into Oregon, Washington and Montana, continually studying the general botanical and agricultural features of the regions traversed, taking samples of their soils and subsoils, and specially noting the depths of the soil mass and the penetration of the roots for the bearing upon vegetative life under arid conditions. It would be easy to infer that the knowledge and experience thus accumulated went directly to increase Hilgard's efficiency in his professorship, whose obligations he accepted punctiliously always, had he not told us explicitly that "Without the wider experience given me by these explorations, which I have taken advantage of extensively, too, for my book on 'Soils,' I should not have been able to give my series of publications the scope they have had." But the Board of Regents, we learn, were at first inclined to read neglect of duty in these scientific employments, and were brought to correct their layman's view only after an unpleasant season of conversion.

From the moment of his recorded first surprise at finding green vegetation sustaining itself, notwithstanding the arid climate in many districts of California, the unraveling of the operative causes was a primary theme of Hilgard's thought until he had deciphered the riddle. That was characteristic both of his acute observation and of his pertinacity in analysis. Much corroborative detail that would have been embodied in a report upon the results of the Transcontinental Survey was withheld from direct publication, first by the suspension of the survey and later by a fire that destroyed the collected material. But his demonstrated conclusions regarding the connected subjects of "alkali-soils" and "arid fertility," as announced in an important group of papers, are undoubtedly one of his weighty original contributions. Even such a sorely condensed review as this of what Hilgard's name will stand for cannot refrain from some estimate of his success and his priority in that field. And we shall be safest in borrowing the words of his own summary: "I soon recognized, touching this matter of preferred interest, that arid climates and soils are miscalled 'semitropic,' being indeed the very reverse of tropic; and that such soils will, as a rule, be calcareous, through the absence of the leaching process, so that arid vegetation is practically lime vegetation. Now lime vegetation is characteristic of fertile soils, the world over; hence, arid countries should be fertile whenever water is supplied. That this is so is proved by the history of ancient civilizations, which flourished mainly in arid countries—Asia Minor, Egypt, India, Mesopotamia. The exceptional and lasting fertility of arid soils is explained not only by their high content of plant food, but by the fact that as clay substance is but scantily formed under arid conditions, the sandy and silty soils so formed are pervious to air, water, and plant roots to a depth rarely reached in a humid region, thus rendering accessible to plant growth a soil mass many times greater, measured by feet instead of inches and conditioning drouth resistance. Also under proper cultivation rendering fertilization unnecessary for a long time, while the soils of the humid regions must be thus supplemented in a few years. It appeared also that the same is true of the despised alkali-soils in which an excess of salts has accumulated, so soon as that excess is removed by drainage. The enormous areas of saline deserts can thus be made available for food production whenever the increase of the earth's population shall render it desirable and feasible to effect this reclamation. I was the first to recommend the use of gypsum upon 'black alkali' soils to change the carbonate of soda into the sulphate."

Hilgard continued for some ten years to make an attractive center of the family home that had been occupied soon after the removal to Berkeley. His "retirement" affected professional obligations merely, leaving unimpaired the traditions of rich years devoted in that circle to all that can make life best worth while. Many have marveled that a fighting exponent of personal views in the public arena can be radiant of unassuming gentleness at home; as Hilgard was and Huxley before him, because men of that stamp see a conflict of ideas apart from contentiousness. Many are regretting the limited horizon of the typically modern scientific man, when they remember in sharp contrast Hilgard's catholically embracing concern with the entire gamut of human endeavor. Perhaps the mold was broken in which such men were formed, when the full cosmopolitan range of influences that made them was compressed into an eager haste to acquire paying control of a specialty.

Hilgard lived to his end in a fashion that allowed his span of over fourscore years to set at naught the dictum of the psalmist. There was a gradual decline of physical vitality, natural to advanced age, to be sure; but it was marked in him by little else than a mellowing. And so the close on January 8, 1916, for the daughters who had shared his sorrow at the premature bereavements of son and of wife, was to be read in symbols of fulfillment rather than in sequence with those early losses. When the ripeness of time came, Hilgard could derive legitimate pleasure from his public scientific honors: from the rarely bestowed "Golden Degree" by which Heidelberg commemorated his completed half-century of distinguished record; from the Doctor of Laws granted him in superposition by Columbia, Mississippi, Michigan; from the medals awarded in Munich, Paris, and elsewhere. But he was sensitively humane more than the stiffness of such academic conventions can express. The "thought of his heart" was interwoven with California, through his unique function and chance to retrieve her in perpetuity from the harm of false counsels in the field of his responsibility.

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J. M. Crafts

NATIONAL ACADEMY OF SCIENCES
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OF

JAMES MASON CRAFTS

1839-1917

BY

CHARLES R. CROSS

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JAMES MASON CRAFTS

1839-1917

BY CHARLES R. CROSS

James Mason Crafts was born at Boston, March 8, 1839. His father, Royal Altemont Crafts, was a well-known merchant and manufacturer of woolens of that city. His mother, Marian Mason Crafts, was a daughter of the noted lawyer and statesman, Jeremiah Mason, of Portsmouth, New Hampshire, and later of Boston. He married Miss Clémence Haggerty, of New York, June 13, 1868, who died in 1912, several years before her husband. His death, after some years of impaired health, occurred at his summer home at Ridgefield, Connecticut, on June 20, 1917. He is survived by four daughters, Mrs. Russell S. Codman of Boston, Mrs. Gordon K. Bell of New York, and Misses Elizabeth S. and Clémence Crafts, of Boston. The two last-named have more recently devoted themselves most earnestly to the cause of the French War Charities.

As a boy, young Crafts had an unusual fondness for scientific subjects and carried on much systematic experimentation in a laboratory of his own. His liking for science was fostered by the prominence given to it in the Lowell Institute lectures and by the interest shown in his own studies by his elders of scientific training, especially by Professor William B. Rogers, later to become the founder of the Massachusetts Institute of Technology. He entered the Lawrence Scientific School and pursued there the course in chemistry, graduating with the degree of S. B. in 1858, but continued his studies under Professor Horsford during a portion of the following year. He spent the next few years in study abroad at Freiburg, Heidelberg, and Paris. The University of Heidelberg was then at the height of its scientific reputation, since Helmholtz, Kirchhoff, and Bunsen filled the three leading scientific professorships. Mr. Crafts came into intimate relations with

Bunsen and had the good fortune to work under him, acting as his assistant while the new art of spectrum analysis was in process of application to the discovery of what were then called the "new metals." At Paris he studied under Wurtz and published a number of scientific papers, both under his own name and also jointly with Charles Friedel. Friedel and Crafts became close personal friends and co-workers in many scientific researches in later years.

In 1866-7, having returned to this country, Mr. Crafts spent a short time in professional work in the inspection of mines. Upon the opening of Cornell University he became, in 1868, Professor of Chemistry, in charge of the department, remaining there until 1871.

In 1869 the resignation of Mr. Charles W. Eliot, Professor of Analytical Chemistry and Metallurgy in the Massachusetts Institute of Technology, upon his election to the presidency of Harvard University, followed by that of Mr. Francis H. Storer, Professor of General and Industrial Chemistry, who had in 1870 accepted the position of Professor of Agricultural Chemistry in the newly organized Bussey Institute, practically vacated the department of its professors.

The corporation desired that the new incumbents of the positions should be especially interested in the teaching and development of Industrial Chemistry and Analytical and Organic Chemistry respectively. To fill the first of these vacancies Professor John M. Ordway was chosen and Professor Crafts for the second. His ability and reputation were such that his accession to the staff of the institute was warmly welcomed both by teachers and students.

There was no graduate instruction given in the institute at that time and there were few students who made a specialty of chemistry. Those who did, however, found themselves fortunate in receiving a training which aimed to make scientific men as well as skillful analysts. Professor Crafts encouraged them to undertake "the investigation of unsolved problems," and a number of very creditable published papers resulted. His scientific standing at this time was recognized in his election to membership in the National Academy of Sciences in 1872.

He continued his teaching and the development of the laboratory until 1874, when impaired health made it advisable for him to relinquish this taxing work. Personal reasons and the scientific resources open to him in Paris, whose value he had already learned by experience, led him to take up a temporary residence there. It was expected that this would be only for a year or two and he remained a member of the institute faculty until 1880, when it had become apparent that his stay abroad would be indefinitely prolonged. He therefore resigned his position, much to the regret of his colleagues.

While on active duty Professor Crafts was an earnest worker in the faculty, especially in the furtherance of a rigid and broad scientific training. With several others he was particularly interested in the establishment of advanced courses of study and research in chemistry, physics, and other branches which should lead to a higher degree. That of Doctor of Science was then established, although it has never been given. The time was not ripe for such work. Indeed, it was not until 1907 that the institute conferred any degree of Doctor, which was Ph.D.

Professor Crafts remained in France until 1891, during which time he was almost constantly engaged in research, chiefly at the École des Mines, and very largely in conjunction with Friedel. These labors bore important fruit, as is manifested in the long list of valuable papers published by them, chiefly in the *Comptes Rendus* and the Bulletin of the Chemical Society of Paris. Among these researches that relating to the use of aluminium chloride as a method of synthesis, the "Friedel and Crafts Reaction," has proved to be of exceedingly great value. The Friedel Memorial Lecture given before the Chemical Society of London in 1900 by Professor Crafts contains a very complete résumé of Friedel's work, with a charmingly written brief sketch of his life history, which considers incidentally conditions relating to scientific preferment in France and moreover throws an interesting light on some phases of the religious views prevalent in that country at that time and especially of those which existed in certain provinces a generation earlier. It is an astonishing revelation of intolerance to learn that the wife of Friedel, when a child, lived "near Nismes in a house where the coffins of her relations occupied one of the drawing rooms because as Protestants they were refused Christian burial." The sanitary results of such a custom may be imagined.

The studies referred to were recognized by the award to Professor Crafts in 1880 of a Jecker Prize of 2,000 francs by the Paris Academy of Sciences, "for his researches relative to organic chemistry." In 1885 he was further made a Chevalier of the Legion of Honor.

During these years he also began an important series of researches relating to high-temperature thermometry, to which fuller reference will be made later.

Upon his return to this country he was made a member of the corporation of the Massachusetts Institute of Technology and was also invited by President Walker again to join the instructing staff. He became Professor of Organic Chemistry in 1892. Regarding the appointment President Walker said: "The accession of a chemist of Professor Crafts' reputation, a teacher of his experience and exceptional powers of inspiring interest and enthusiasm on the part of the students, marks an era in the history of the Institute." He continued to occupy this position for five years, carrying on his researches meanwhile, when he was called on to take up new and heavy duties.

The sudden death of General Walker, in January, 1897, made a vacancy in the office of president of the institute, which it was evident would be extremely difficult to fill. The number of available men proved to be very small, and after much search the committee charged with the business of selection found itself unable to come to a decision. Professor Crafts, who had been the spontaneous choice of the faculty as its chairman, had already been urged to accept the presidency, but had absolutely refused even to consider this, being entirely unwilling to break off his scientific researches and engage in executive work. A few months later, however, conditions had arisen which led him to see that it was very necessary for the best good of the institute that he should reconsider his determination. He was therefore made president in 1898, which office he held for two years.

Soon after his accession to the presidency he received the degree of LL. D. from Harvard University.

As an executive officer, President Crafts showed the same characteristics which had been evident in his earlier career. His long experience as a scientific man and acquaintance with scientific education in this country and abroad, together with his wide knowledge of the industries, gave him a very clear and true perception of the needs of a school of technology which should train men capable of meeting the professional calls of the future as they should arise, whatever these might be. In his annual reports to the corporation there is much regarding the general considerations which apply to technological education that is valuable at the present day. The occasional addresses delivered by him were of great interest and gave evidence of a remarkable breadth of literary and historical knowledge entirely apart from science. It is to be regretted that they were not published. While he was greatly hampered by lack of means, nevertheless important extensions were made in the facilities for instruction and research in many directions. A timely bequest enabled the institute to erect the Henry L. Pierce Building under his direction, which was not only excellently adapted for the purposes for which it was planned, but also, while of simple architectural design, was very satisfactory in its external appearance.

In his relations with his faculty he was invariably fair, just, consistent, and considerate of all interests. Measures which he presented to them he urged wholly on their merit and never through the authority of his position.

During the administration of President Crafts, two educational questions arose which are especially worthy of mention here.

At the wish of the Secretary of the Navy, there was laid out a three-year course in Naval Construction, particularly of war-ships, to be pursued by selected graduates of the United States Naval Academy. Various hindrances delayed further action in this direction for the time being, but the outcome was the establishment, a few years later, of such a course along the lines originally laid down, which has continued up to the present time.

President Crafts, like many others at that time and since, was strongly impressed with the belief that it would be greatly to the advantage of scientific and technical instruction in this country if in some way an arrangement of affiliation could be brought about between the Lawrence Scientific School of Harvard University and the Institute of Technology, so that the two institutions should work in harmony and join their forces for a common end as far as might be practicable, while retaining the independence of each.

Informal consideration of the matter led to the appointment of a committee composed of members of the corporations of the two institutions. The various possibilities of co-working were considered and a detailed plan was drawn up which was acceptable to the members of the joint committee. President Crafts felt very earnestly that the course of action proposed would be for the best good of both institutions at that time and in the future. But as this came to be considered more widely by those with whom the final decision rested, difficulties arose which ultimately led to its abandonment, though with the expressed hope "that as friends and earnest promoters of instruction we can so direct the course of our respective institutions that they shall mutually help one another and avoid duplication of work."

This termination of the endeavors of the committee was a great disappointment to Professor Crafts, not because a plan which he favored had failed, but rather because in his judgment a promising opportunity for the advancement of scientific education had been lost.

The labors of the presidential office, although he carried them with complete success, were not really attractive to him, especially as he found that they necessarily precluded a continuance of his scientific work, and, unwilling to set this aside permanently, he resigned the presidency in 1900.

It was felt by all his colleagues that to lose him entirely would be most unfortunate. A private laboratory was therefore provided for him, and this he fitted up according to his wishes as was necessary for the continuance of his researches.

As a result of his work at this time there appeared several papers on Catalysis. He devoted himself particularly, however, to another line of research.

A few years after the beginning of his long term of labor in Paris, he had entered upon a series of physical researches. Measurements of the density of iodine vapor and like investigations in which he engaged naturally led him to begin a precise and methodical study of the peculiarities of the mercury thermometer of precision and the sources of error which are liable to occur in high-temperature measurements, and likewise to the accurate determination of the boiling points of various substances—a matter of great importance in view of the desirability of securing fixed points of reference. The value of the results of these early studies has been strikingly confirmed by their agreement with more recent measurements. In recognition of this important work the American Academy of Arts and Sciences, in 1911, awarded to Professor Crafts the Rumford Medal, the terms of the award being "for his investigations in high-temperature thermometry and the exact determination of new fixed reference points in the thermometric scale."

To the continuance and extension of his researches on thermometry he now applied himself in his new laboratory. He devoted several years to designing and perfecting the elaborate apparatus needed for his purpose, and when this was finally completed to his satisfaction he entered upon the actual work of experimentation about 1904.

In the summer of 1911, while abroad, he suffered from a severe attack of neuritis, from the effects of which he never wholly recovered and which precluded further extended work in the laboratory. Though no longer able to continue this, however, he devoted himself to putting his experimental results into form for publication, and in 1913 there appeared in the *Journal de Chimie Physique,* Part 1 of an extended paper entitled "Points fixes de thermométrie entre 100° et 400°. Tensions de vapeur de la naphtaline, de l'eau et de la benzophénone."

This contains an exhaustive description of the form of apparatus used by him in these studies, embodying many new devices of his own. A constant volume nitrogen gas thermometer, a special type of open manometer, and also a new form of ebullioscope were employed. Of available substances tested for constancy of vapor pressure, only water, naphthaline, and benzophénone proved to be sufficiently stable. Water was found to be absolutely so between 70° and 170°.

It is the result of his studies upon naphthaline, however, to which this paper especially relates. His measurements, given in extended tables of pressure boiling-point values, run from temperatures 171° to 270° and pressures 231 mm. to 2,149 mm., the relationship of temperature to vapor pressure being capable of representation throughout by a formula. He found, moreover, that naphthaline, when properly prepared and used, retained a constant boiling point during continued boiling for twelve months. He concludes that this material has "a value almost equal to that of water for establishing temperatures," a result which, as he remarks, completely confirms his early conclusion, published in January, 1883.

A second part of the paper entitled "Tensions de vapeur de l'eau entre 40° et 100°" appeared in the same journal in 1915, whose object, as stated, relates to a much-needed revision of Regnault's tables concerning the vapor pressure of water. These tables are still used, even in their original form, although from various circumstances of Regnault's measurements, probably unavoidable in the state of scientific knowledge at the date at which they were made, there are in some parts errors which are by no means negligible. In others of Regnault's results, as, for example, the tables for the expansion of mercury, errors of as much as one-tenth of a degree are present. Regnault's tables as corrected by later scientists, of which those of Broch and Wiebe are considered the best, are probably exact between 80° and 100°, but at temperatures between 0° and 60° are open to question because of considerations which they have overlooked but which are fully considered in this memoir. These relate both to the degree of exactness of mercury thermometers, which have always been chiefly used, and to the accuracy of the determination of the freezing and boiling points of water employed in their calibration.

Regnault, while taking the utmost precautions known to him as necessary, worked at a date when various important facts as to the construction and use of thermometers of precision were still to be ascertained. The early researches of Professor Crafts in 1880 first showed how certain errors in these matters could be reduced to a minimum. Furthermore, an entirely erroneous assumption has been made as to the character of Regnault's mercurial thermometers, which have been assumed to be made of "cristal de Choisy-le-Roi," while in fact they were of ordinary French glass. Were these still in existence a comparison with the hydrogen thermometer would give new importance to the work of Regnault. But, to quote Professor Crafts, "Malheureusement, par un acte de vandalisme extraordinaire, tous les appareils précieux de Regnault ont été détruits méthodiquement pendent l'occupation de Sèvres par les Allemands."

It was the original intention of Professor Crafts to undertake a series of measurements of the vapor pressure of water between 45° and 140°, making use of the nitrogen-gas thermometer devised by himself and described in part 1 of his paper under consideration. But, unfortunately, the condition of his health rendered this impossible. He was able, however, by the use of an indirect but accurate method to determine values from 135° to 230°.

Two vessels of proper construction were placed side by side, one containing naphthaline and the other water. By suitable adjustment of pressure these were brought to the same boiling point within a few tenths of a degree, the pressure being measured by the manometers. The slight temperature differences existing between them could be measured accurately by a carefully calibrated and tempered mercury thermometer with a probable error of the result of about two one-hundredths of a degree. The method proved to be a very satisfactory one.

The results thus gained agree closely with those of Holborn and Henning, published subsequently to the actual completion of the measurements of Professor Crafts, in which the temperatures were measured by a resistance thermometer.

The latter part of the paper is devoted to a consideration of the applicability of various empirical formulæ which have been proposed to give the relation between vapor pressure and temperature. A brief article relating to this subject was published by Professor Crafts in *Comptes Rendus,* December 22, 1913. In the present paper he discusses at length three particular formulæ and considers their relations to many substances, with results shown in extended tables. He finds that these, each for a particular class of substances, may be of great service. The substance naphthaline, with which he had made an additional series of 250 experimental determinations with a new form of hydrogen gas thermometer at pressures from 80 mm. to 2,200 mm., shows so close an agreement with the formula proposed that experimental results which it fails to represent are probably due to errors in measurement.

It was the intention of Professor Crafts to complete the paper on vapor pressures by one containing the results of his measurements upon the substance benzophénone, which, however, he was not able to prepare for publication.

These papers form a fitting close to his labors, but at the same time show how great a gain to science might have been wrought had his physical strength been equal to his intellectual and experimental abilities.

Professor Crafts was a member of a number of learned societies besides the National Academy, among which were the American Academy of Arts and Sciences, the American Association for the Advancement of Science, the American Chemical Society, the Washington Academy of Sciences. He was a Corresponding Member of the British Association and an Honorary Member of the Royal Institution of Great Britain. His club membership included in Boston the Somerset and Country Clubs and in New York the University and Technology Clubs, of which last he was an honorary member. His religious affiliations were with the Episcopal Church, and for a number of years he was a vestryman of Trinity Church, in the city of Boston.

The personality of Professor Crafts was such as to impress itself upon the memory of every one who came in contact with him. He was not only a scientist of the first order, but also a gentleman of the highest culture. It was a great pleasure to his younger colleagues, who frequently sought his laboratory for advice, to enter into conversation with him regarding collateral subjects and so to draw upon his long experience and seemingly inexhaustible knowledge.

His studies involved the greatest nicety of construction of the apparatus used, which was largely done with his own hands. While his genius was by no means merely a capacity for taking infinite pains, this element of success was possessed by him in a surpassing degree.

His manner was quiet and gentle. His opinions were definite and positive, but he invariably showed great respect for the views of those who differed from him. The only thing which he seemed to hold in contempt was bad work in pupil or professor. He did not care in the least for display of any kind, and while valuing approbation at its proper worth, no desire for it ever influenced his actions. No man could have been more absolutely free from self-seeking. He had the affection of his colleagues and pupils and of the whole staff of mechanicians and janitors as well. A certain reticence of manner, wholly superficial in its character, served to protect him from triviality in those who had no claim on his attention. But when occasion called for it he showed the keenest sympathy for such as were in trouble of any kind. Speaking for those who knew him well, our remembrance of him is more and more strongly cherished with the lapse of time.

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A. S. Packard

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ALPHEUS SPRING PACKARD

1839-1905

BY

T. D. A. COCKERELL

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ALPHEUS SPRING PACKARD *

1839-1905

BY T. D. A. COCKERELL.

Alpheus Spring Packard, Jr., zoologist and teacher, Professor of Zoology and Geology in Brown University, was born at Brunswick, Maine, February 19, 1839, and died at Providence. Rhode Island, February 14, 1905. His father, Alpheus Spring Packard, D. D., was Professor of Greek and Latin at Bowdoin College; his mother was Frances Elizabeth Appleton, daughter of the Rev. Jesse Appleton, president of Bowdoin College. Both the Packards and the Appletons are of English ancestry, but have been in New England since the seventeenth century. Samuel Appleton, born in England in 1624, came to Ipswich, New England, in 1635. Four generations, residing in the same region, come between him and Professor Packard's mother; and the several marriages bring into the stream of inheritance the families Oliver, Baker, Sawyer, Hubbard and Means. The Packards trace their ancestry to Samuel Packard, who came from Windham, England and died in 1684. His son, Zaccheus, married Sarah Howard, who was brought up in the family of Miles Standish. Their son, Solomon, married Susanna Kingman, and their son, Jacob, born in 1720, married Dorothy

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*It has been possible to prepare this memoir only because Mrs Packard, with the greatest kindness, transmitted the materials concerning her husband which she had collected and preserved in four large volumes. She also answered all my questions, and secured information from others. I have thus been able to examine Packard's diaries, and numerous letters and other documents; making a brief summary and abstract of materials which, if fully utilized, would suffice for a book. I am also indebted for information and other assistance to Dr. Charles W. Packard, Mrs. Frances Packard McClellan, Mr. A. A. Packard, Dr. L. O. Howard, Dr. Wm. H. Dall, Rev. C. C. Carpenter, Prof. James Schouler, Dr. Nathan Banks, Dr. Glover M. Allen, Mr. Charles W. Johnson, and the editorial offices of the "Independent" and "Youth's Companion"

Perkins in 1742. They had a son, Hezekiah, born 1761, who, in 1794, married Mary Spring. These were the parents of Professor Packard's father, Alpheus Spring Packard, 1798-1884.

The Packard family has produced in America a remarkable number of accomplished persons. The National Cyclopedia of American Biography cites eleven, nine of whom are known to be descendants of Samuel Packard, of Windham. A moderate search through recent biographical works and bibliographies reveals the names of twenty other Packards, who have published books or articles, or are otherwise noteworthy. Presumably nearly all (at least) of these belong to the same old New England stock, as there is no Packard family of any note remaining in England. No Packard is mentioned in English biographical dictionaries or in a recent volume of the English "Who's Who." The talents and opportunities of the Packards have led them in many directions. We find representatives of law, education, medicine, architecture, poetry and other fields of activity, but their main vocation has been the ministry until comparatively recent years. Professor Packard, when questioned in 1901 regarding the source of his scientific interests, replied: "I may say that the love of flowers, animals and natural scenery was inborn in me. My ancestry on both sides were ministers, and we never had a naturalist in the family, but my father was extremely fond of and appreciative of natural scenery, and was interested in history and archæology. As a child I was very fond of flowers, as were my parents, and as early as I can remember had a flower-garden of my own. When about 14-15 I began to collect minerals, and then shells. My zeal for collecting and forming a museum led an older brother, who also had such tastes, to give me his cabinet, containing curiosities, shells and minerals. I was also an omnivorous reader, devoured all the books on natural science in the library of Bowdoin College, where I was kindly allowed to browse long before entering college. When about 16-17 I collected insects in considerable numbers. I was also aided by a maiden lady in Brunswick, Maine, who told me about shells, and aided me in naming my native plants. I formed a herbarium before entering college. From Miss Ann

Jackson, when a boy, I first heard of Lamarck, and of his classification of shells, and of the Lamarckian genera of shells. With, then, an inborn taste for natural history, an aversion to business, and a fondness for books, my deep interest in animal life was sustained and I was impelled to devote my life to biological study. All through college I corresponded with Professor Baird, assistant secretary of the Smithsonian Institution, also with conchologists and entomologists, and this was a constant stimulus to the natural zeal and interest, or passion, for biology which has influenced my life. Also, I was a born collector, though I have now no large collections."*

Packard never knew his mother, who died a few months after he was born; but in other respects his early environment was extremely favorable. His father was a man of noble character and lovable personality, always ready to give wise counsel and encourage the intellectual and moral development of his children. Alpha, as the child was called, was not left without a woman's care; his aunt, Miss Sarah S. Packard, took charge of the household and the little baby was the object of her most devoted care. In 1845 his father married a second time. There were three brothers and a sister older than Alpha; and the old grandfather, Hezekiah Packard, lived until 1849. The family life was extended, as it were, into that of the college, and every circumstance tended to give young Packard permanent and genuine interests, developing as he grew. He suffered from a congenital defect of the palate, which somewhat affected his speech, though he was able to sing, and in later life was very successful as a lecturer. Partly as a result of this, he shrank from general society, though much attached to his friends and readily attracted to those who had common feelings and interests. He kept a diary during the greater part of his life, and from this record it has been possible to follow the development of his activities without difficulty.

The earliest journal found is dated January 1, 1854, and contains this entry: "I had for my New Year's present 50 cents; with it and some other money bought Layard's *Nineveh.*" He was not quite 15 years of age.

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* *Popular Science Monthly,* April, 1903, p. 519.

On March 14, 1854, a manuscript periodical was begun, under the editorship of John N. Wilder, A. S. Packard, Jr., and S. P. N. Smyth. The contributions are not signed, so it is impossible to say which were written by Packard. The journal was called "The Star of the East," and immediately under the title appeared the motto "Excelsior!". Apparently thirteen numbers were issued. In the first editorial we read: "The object of our paper is to teach us to write and compose better, so that if we should ever be called upon to edit a larger paper, we should be better fitted for that office. Our paper will be devoted to literature, amusements and the news of the day, and we shall ever be zealous for the cause of the poor slave. . . . In most every number there will be a little poetry, original or taken from other authors."

In dealing with public affairs, "The Star of the East" took a very strong stand against slavery, and supported the English, French and Turks in the Crimean War. The following is interesting reading at the present day:

"The Turkish war is an event of great importance. The Russians have a great many nations subject to them. So has Austria, if Austria joins Russia, all these nations will rise and throw off the chains of bondage. Thousands will be pouring in from all sides. England and France are sending troops to attack Russia and help the Turk, and there will be a general war in Europe. It has different effects on the missionaries also. The missionaries in Turkey pray for the success of the Turk. The Koords, a lawless set of people in Asia Minor, are committing great ravages during the absence of the Turkish soldiers . . . "

There is an original poem lamenting the fate of Hungary, subject to the domination of Austria. A patriotic poem closes with the words:

Hurrah now all! for Washington.
And then for our good land
And let each one for liberty
New pledge his heart and hand.

Enough has been given to show the temper of these fifteen-year-old lads; their serious outlook on life and determination to make something of themselves. At this period, young Packard also made a cabinet and began to develop a collection of natural history objects and other miscellanea. "Father gave me a leaf from the Ilex over the tomb of Virgil, a leaf from a tree planted by Cowper at his summer house at Olney, a leaf from a Yew tree over his grave. . . . They will be fine to put into my cabinet." The Ilex is of course not the holly, but the Quercus Ilex, or evergreen oak. Before long the principal part of the collection seems to have consisted of shells, and the diary contains innumerable references to conchology. Presents were received from numerous friends, and are all faithfully recorded. Books on shells were borrowed whenever possible, and gradually the specimens were named. On March 17, 1855, Packard was asked what department of Natural History he liked best, and answered without hesitation: Conchology.

The following extracts from the diary show the range and character of Packard's interests as a boy:

"Nov. 14, 1854. Went over to the library, and got out Bayard Taylor's *Eldorado.* Goldsmith's *Animated Nature,* it has something about Conchology in it. I read *Lalla Rookh* yesterday, it is a most charming and beautiful book, and gives some ideas of eastern customs and life which I never knew before. There are some most beautiful passages in it. *Eldorado* is fully equal to his *Journey in Africa.*

"Nov. 16. Finished *Eldorado,* it is very interesting. I have read Goldsmith's *Animated Nature,* parts of it. About Conchology and other parts I like very much. Went to library and got out 4th vol. Encyclopedia Americana; an interesting article on Conchology in it.

"Nov. 18. Oh dear me, I have got to go to school. I want to have another week to read and do some work, I don't want to study yet.

Jan. 1, 1855. His parents gave him Principles of Zoology, by Agassiz and Gould. "A valuable book and just the thing I wanted. I cannot but think how kind my parents are to me, and how much I owe to them."

"Jan. 6, 1855. Went to the library and got an article on Mollusca, with a life of Cuvier in it, and one volume of Ree's Cyclopedia . . . containing an interesting article on Conchology. I think that I am very fortunate about getting books on that subject, which is so interesting to me, but the rest of the family except Osgood laugh at me about it.

"Jan. 12. I wrote this evening my composition on the life of Cuvier. A very good subject.

"Jan. 20, 1855. Got the key to the Peucinian Library . . . got out one vol. *Naturalist's Library,* containing the life of Lamarck, and one vol. of Journal of Science.

"Jan. 24, 1855. I have skated down to school every day now. We went down to Humphrey's mills in 15 minutes, 4½ miles."

"Feb. 5, 1855. I have read a good deal today in my *Naturalists' Library.* Oh, that I could wander around the earth to collect specimens of Natural History! It seems to me that if I could know all about botany, mineralogy, geology and conchology, and knew how to stuff animals and birds, and to preserve insects and keep shells, that nothing could be more pleasant, provided that I had the *finances.*

"Feb. 6. I am reading now Howitt's *Homes of the Poets,* it came from the Peucinian Library. Oh, what a treasure is that Library for me! I am thankful that I have such opportunities to read. I don't know what I should find to do without books.

"Feb. 7, 1855. I wish that I had a fondness for poetry. Almost every long piece of poetry I read, I labor through. I mean to read some this vacation.

"Feb. 13, 1855. I am reading now with great interest Hugh Miller's Autobiography, or *My School and School Masters.*

"Feb. 14, I have finished Hugh Miller's Autobiography. I think he thinks considerable of himself, but still I think a good deal of him. I mean to read his works.

"Feb. 15, I finished *Foot Prints of the Creator.* The last part is much more interesting than the first, and I like the book very well. I began on his *Old Red Sandstone.* A very interesting book.

"March 17, Went over to the Peucinian Library and got out the 5th vol. of the *Naturalist's Library,* on the Pachyderms, with a life of Sir Hans Sloane, it is *extremely* interesting to me, he was the founder of the British Museum, he spent his whole life in making the most valuable private collection I guess that any individual ever possessed.

"Jan. 24, 1857. I must now gain a thorough knowledge of Comparative Anatomy. I intend next summer to do a good deal of dissecting, and shall devote myself much more to collecting insects, etc., and dredging, etc., last summer I only collected about two hundred insects, when I ought to have collected three times the number, and I must give more attention to rearing caterpillars. I intend next summer to have a fresh and salt water aquarium. This is the only way to study the habits and economy of animals. I must also use my microscope more, etc. I did not do near as much last summer as I ought to. In fact I have only got my ideas of these things this winter. May none of my enthusiasm for these affairs be cooled down by this cold weather."

Thus the lad at the time of his admission as a freshman to Bowdoin College in the fall term of 1857 was already mature minded, with keen intellectual interests of many kinds. His course in life was already determined; he could never cease to be the naturalist he had already become, nor could he, on the other hand, become a narrow-minded specialist. The college, Agassiz, and the rest, all still before him, did not create his tastes or aptitudes; they merely afforded the means for their additional development.

The diary of September 4, 1857, has this entry: "I am getting on very well in college; have no trouble as yet in recitations, much to my joy, for I had dreaded it very much." At the same time Packard began a "course of geological reading" on his own account: "I shall read the elements, etc., of the science, then the particular surveys of different States, etc., hoping thereby to gain as good a knowledge of Geology as I can without a teacher. . . . My interest was greatly excited by seeing the specimens of fossils, etc., in Boston." The diary enumerates the various geological works read in rapid succession, but there was also time for Gibbons' "Decline and Fall," which he found very interesting.

It was characteristic of Packard that his geological reading soon spurred him to action, and he writes: "I intend to make a thorough survey of every part of this town, make a plan of

June 10. "Our new Natural History Society formed: am elected secretary."

August 27. "Been trying to identify my Polyzoa. Can only make out the genus. I've formed the idea of making for my private use a manual of Marine Zoology like Gosse's, adapted to New England." The writings of Gosse, the English zoologist, were highly valued by him, and greatly stimulated his interest in Marine Zoology.

September 1. "Commenced today on my *New England Marine Zoology*. I shall make it as complete as possible, making ink sketches of each genus. It will be good practice, especially drawing the animals."

November 12. "Been studying up on my Geometridæ this P. M. It is pleasant work. I begin to see now what is to be done in the way of studying up this family. I must attend to the pterology especially, and the anatomy of the organs of the head." In after years he monographed the Geometridæ of the United States.

In 1860, after returning from Labrador, "Sent an article on Labrador to the *Tribune*. Hope they will publish it." In the same year he wrote papers on Economic Entomology for the *Maine Farmer,* and thus began the series of entomological writings, which continued for forty-five years. During the first half of 1861 much dredging was done in the vicinity of Brunswick.

After graduating, in 1861, Packard conducted members of his class on a summer voyage to the Bay of Fundy. He also worked for the Maine Geological Survey, and discovered a deposit of fossils which determined the age of the rocks in the Fish River Region.

On October 8, 1861, Packard went to Cambridge to study in the Lawrence Scientific School under Agassiz. He took the rooms which had been occupied by his friend Morse. He writes to his father: "I went into the museum and saw the Professor, who put me to work on a moth, and I have been several hours looking at the wings and their make. There is Shurtleff by me studying Entomology, and Scudder will be in soon. Everything looks very pleasant there."

On October 31 he writes: "I feel well established here now.

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This plan, in its essential features, was actually carried out. Packard studied human anatomy and medicine for portions of the following three years, and received his M. D. in 1864 from the Maine Medical School at Bowdoin College. Those were the days when doctors were easily made, and some of the leading subjects of study in the modern medical schools had not even been heard of.

On January 11, 1862, he writes to his father:

"I have been informed indirectly that the Professor is desirous of having me as an assistant in the Entomological Department of the Museum. He has several times spoken to me of my industry, and was much pleased with my arrangement of the wasps. Yesterday I spoke to him about some interesting affinities of a moth to another insect far removed in structure, and he was so much pleased with my discovery that he told me to make a communication to the Boston Society about it, and show Entomologists in the country how they studied insects in the Museum."

A few years later Packard published a revision of the wasps referred to, describing many new species.

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A letter of October 5, 1863, tells of the arrangement finally made with Agassiz:

"Professor A. comes up from Nahant occasionally. When he saw me, he asked me if I could go to work and unpack, label and arrange the insects. I told him I could, but that the only thing in the way was the money question. He said he would give me $400 a year, and part of my time to work for my private study, an arrangement very agreeable. . . . I shall have just enough to live upon, which was all I dared to ask for the first year."

It now seemed that Packard might settle down to a scientific life, with every prospect of becoming one of the permanent curators of the Museum of Comparative Zoology. Unfortunately, however, matters took a new turn, and difficulties arose between Agassiz and those working under him. Trouble had been slowly brewing for a long time, owing to differences of opinion concerning the duties and obligations of the men in the Museum. The whole matter has been discussed many times and from different angles, and we are obliged to conclude that the fault was not all on one side. Marcou has given a lengthy and apparently just account in his *Life, Letters and Work of Louis Agassiz* (vol. 2, pp. 99-101). For the junior assistants, matters came to a head when a sheet was published containing "Regulations for the Museum of Comparative Zoology." This document was obviously designed to prevent assistants from working for themselves during office hours, and in general, to bring the men definitely under the control of the curator, *i. e.,* Agassiz. Its provisions do not now appear particularly unreasonable; in fact they closely resemble those in force at the British Museum. On the other hand, the young men were paid very little for their services (it was the best Agassiz could do), and were beginning to feel their mature powers, and to think of their place in the world. To Agassiz, the Museum was the first thing, to them it was rather a means toward an end. So Verrill, Putnam, Morse, Packard and Hyatt left Cambridge and sought other employment. They continued their work under other auspices, where they could be more independent. In the case of Packard, at least, there was never any personal quarrel with Agassiz, and as the years passed the respect and affection of the younger man for the older increased and deepened. Agassiz remained a kind friend, and it was through his nomination that Packard was elected a member of the National Academy of Sciences in 1872.

In the summer of 1864 the artist William Bradford, of New York, organized an expedition to Labrador, for the purpose of painting icebergs and arctic scenery. Packard was invited to join the party, and was delighted to return in this manner to the coast which had so fascinated him in 1860. This time they went as far north as Hopedale, but were not able to reach Cape Chidley, the northernmost point on the coast. The expedition was successful in every way, and the scientific results were important.

On returning from the north, Packard received a commission as assistant surgeon of the First Maine Veteran Volunteers, under Col. Hyde. He accordingly left for the front, going first to Washington. During this period he wrote no journal, but numerous letters have been preserved. In Washington he found time to confer with the naturalists of that city; Baird, Gill, Stimpson and Ulke. Three days later we find him at Martinsburg, Va., and a little later he was in camp near Strausburg. A letter of February 1, 1865, "Camp near Petersburg," expresses hopes of peace: "600 Johnnies are weekly coming into our lines, and they are deserting home in much greater numbers. It really seems as if something of moment was going to happen. . . . Wouldn't it be delightful if the war should close up soon, and leave me a good chance to collect insects down here in the spring!" However, a letter of March 26th tells of hard fighting: "Our regiment lost more than any other in the division, as they went nearer the rebel breastworks than any other, and the fire, mostly of grape and canister, told fearfully. I do hope early this summer a stop will be put to this severe fighting. It made me heartsick to see the poor fellows. . . . The result of the whole day's fighting was rather brilliant; 5,000 prisoners captured." Peace came and the regiment was mustered out in July. This ended Packard's medical and army life, and he returned to the study of entomology. During the same year his *Synopsis of the Bombycidae of the United States* was published by the Entomological Society of Philadelphia. In it were described numerous new genera and species.

From this time on Packard's scientific activities were more numerous than it is possible to describe in a brief memoir. For a year he was acting librarian and custodian of the Boston Society of Natural History. He was appointed in 1867 one of the curators of the Peabody Academy of Science at Salem, Mass.; and for about two years (1877-8) was the director of its museum, where he founded a summer school of Biology. For a year he lectured on economic entomology at the Maine State Agricultural College, and for several years at the Massachusetts Agricultural College at Amherst. He was lecturer on entomology and afterwards on comparative anatomy at Bowdoin College. In the winter of 1869-70 he visited Key West and the Tortugas for the purpose of studying southern marine life, stopping at Beaufort, N. C., on his way home. The following winter he studied the embryology of marine animals for some weeks at Charleston, S. C. During all this time he continued his original researches, publishing important papers on entomological, zoological and geological subjects. His name became widely known in Europe as well as America, and his place in the annals of science was assured.

In October, 1867, occurred the most fortunate event of his life; he was married to Elizabeth Derby Walcott, daughter of Samuel Baker and Martha (Pickman) Walcott, of Salem. A contemporary letter from his father gives thanks for his singular happiness and good fortune in all his circumstances and relations. In the course of time a son (Alpheus Appleton Packard) and three daughters (Martha, Elizabeth and Frances) were born. Elizabeth Derby Packard died in 1885; the others are still living.

In March, 1867, Packard, with his colleagues of the Peabody Academy, E. S. Morse, A. Hyatt, and F. W. Putnam, founded the *American Naturalist*. The introductory words in the first number state the purpose and character of the magazine:

"In laying before our readers this first number of a popular scientific monthly, we commence a publication in which we shall endeavor to meet the wants of all lovers of nature. The rapidly increasing interest in the study of the various departments of Natural History invites the establishment of a journal which shall popularize the best results of scientific study, and thus serve as a medium between the teacher and the student, or, more properly, between the older and the younger student of nature. . . . : The value of the magazine will depend more on its power to awaken the absorbing interest invariably excited by the contemplation of nature, and of illustrating the wisdom and goodness of the Creator, than on any adornment of style, or cunning devices of the artist. We trust the magazine will be equally welcome to the farmer, gardener, and artisan. We shall endeavor to point out the practical benefits resulting from the study of nature. . . . In our monthly calendar of the periodic return of animals, farmers and gardeners will be warned of the attacks of insects injurious to crops."

The articles were written in a popular style, and were contributed by able writers, so that the journal bid fair to be all the editors hoped. It was an ambitious undertaking, and the Salem naturalists, in making it a success, earned the applause and gratitude of all who cared for the progress of scientific work and education. With volume 12 (1878) the *Naturalist* was transferred to Philadelphia, and was then edited by Packard and Edward D. Cope. Eventually Packard retired from the editorship, and with volume 21 (1887) E. D. Cope and J. S. Kingsley took charge. The *Naturalist* is still published, edited by Professor J. McKeen Cattell. Its function has become more specialized, and there is perhaps still room for a magazine conducted in the spirit of the editorial of 1867. The *Scientific Monthly,* which is widely read by the classes for whom the original *Naturalist* was intended, more nearly occupies its place than the *Naturalist* of today.

In 1869 Packard published his "Guide to the Study of Insects," a work of over 700 pages, with many illustrations. This book contained a summary of the whole science of entomology, as then understood, with numerous original observations. It at once found a public, and went through no less than eight editions, which appeared in 1869, 1870, 1872, 1874, 1876, 1878, 1880, and 1884. It was through the "Guide," more especially, that Packard's name became familiar to entomologists everywhere. The present writer remembers seeing it in England when he was a very young man and hearing it spoken of as a wonderful work. Agassiz praised it warmly, and took it with him to Nahant to study. He declared that copies ought to be placed in all the libraries of the State, at the public expense, and that it should be adopted in all the agricultural colleges as a textbook. Toward the end of his life, Packard contemplated the possibility of issuing a new and revised edition of the "Guide," but never found time to prepare it for the press. After his death, the question of preparing an edition was discussed, but it was considered impossible to bring the work up to date without making virtually a new book.

In the spring and summer of 1872 Packard made his first trip to Europe, going first to England and then to the Continent. On this journey he must have realized with a certain measure of surprise how far his fame as a naturalist had gone. He was everywhere received with kindness and treated as an honored scientific colleague. In England he met Owen, Woodward, Hooker, Westwood, McLachlan, Flower, Lubbock, Douglas, Stainton, Lowne, Michael Foster, Rolleston, Newman, Dallas and many other well-known naturalists. His diary was voluminous, giving many details. "In Gegenbaur's museum an old cabinet with specimens studied by Goethe, while he lived at Weimar, and used to come over here (Jena) and study. Gegenbaur's lecture room old and very small, about 25 average students, often fewer. . . . Saw the foundations of Dohrn's aquarium [at Naples]." In Switzerland he was delighted with the mountains and glaciers, and collected a good many insects. The journey even extended to Scandinavia. He returned by way of England, taking time to visit Wales before sailing from Liverpool. By an unfortunate mischance, he missed seeing Darwin. He had written, asking permission to call, and Darwin replied, inviting him to stay at Down for two or three days. Darwin's health was so poor, that he did not know when he could see him, but if he would come to the house, there would surely be short times when they could talk together. Darwin's letter should have reached him shortly before he sailed, but it was forwarded to Paris by his bankers, and only delivered to him long after in America. His disappointment was keen, for he would gladly have given up his passage to have accepted the invitation.

In October, 1872, he went on a dredging trip in the *Bache,* and much of his time in the following year was taken up with dredging.

In the summer of 1873 Packard was one of the instructors in the Anderson School of Natural History, conducted by Agassiz on the Island of Penikese, off the coast of Massachusetts. On a later occasion, after describing the work of the school and its influence on American Zoology, he said: "The influence of the school was lasting and widespread, and that single season of six weeks was the leaven which leavened the whole lump. I for one wish to bear testimony to the rich and rare experience and advantage, the intimate intercourse with such a mind as Agassiz's, and the inspiration and stimulus and delightful memories of that delightful summer of 1873." As is well known, Agassiz never became converted to the theory of evolution, yet the men who were his students, the younger generation, were without exception evolutionists. Packard, in lecturing at Penikese, expressed his evolutionary views most fully, and Agassiz, who always attended his lectures, never made any objections. On one occasion Packard remarked to Agassiz that he feared his lectures, addressed to young students, must be tiresome to him, but Agassiz replied that he attended them for his own pleasure. Agassiz was extremely kind to the members of his staff and to his students, and finding that some of the latter were short of funds, aided them from his own pocket.

Agassiz died the following winter, and Packard's diary of December 18 has this entry: "Attended the funeral of Agassiz. Much crowded, very impressive, rode to the grave [which was] concealed with evergreens and flooded with flowers. A sad, sad day! Felt his loss as that of an old, dear friend. Felt much drawn to him at Penikese last summer. Learned to love, respect and revere him. He has died mourned by the people of the U. S., as no one else would be."

The next five years were crowded with important activities; perhaps more so than any other period of Packard's life. He continued his work at Salem, and the Penikese summer school having been abandoned, established a more modest "Summer School of Biology" at the Peabody Academy. It was designed primarily for the teachers of Essex County, but students came also from other states. Packard was the director, and the instructors included E. S. Morse and J. S. Kingsley.

A very different Kingsley, the distinguished English author, visited the Packards in 1874. The diary records: "The Rev. C. Kingsley spent the night, with Miss K., a most charming lady. On entering the house Mr. K. began to play with Alpha and Mattie, and insisted on sitting next to Mattie at tea and breakfast. After the lecture sat up an hour talking science. . . . A most genial, cheery old man, and a true naturalist; very enthusiastic, very courtly, and with fine manners."

In 1874 Packard was temporarily connected with the Kentucky Geological Survey, for the purpose of investigating the animal life of the Mammoth Cave and other caves. He was keenly interested in cave life and the evolutionary problems it presented. His collected observations were finally published in a memoir, "The Cave Fauna of North America," by the National Academy of Sciences, in 1888.

In 1875-76 Packard was associated with the U. S. Geological Survey of the Territories, under F. V. Hayden. During the two years previous he had published papers in the reports of the survey, dealing with the insects of Great Salt Lake, the Mallophaga, the Myriapods and the Moths of Colorado. The Hayden survey included biological as well as geological subjects, and in 1876 published Packard's great Monograph of the Geometrid Moths, a work of over 600 pages, with 13 plates. It is from this work especially that Packard's name has become permanently associated with the family Geometridæ. In the latest list of North American moths, 15 genera, 105 species and 21 varieties or sub-species of this group, described by Packard, are recognized as valid.

In 1877, under the influence of C. V. Riley, Congress established the U. S. Entomological Commission, for the purpose of investigating the Rocky Mountain locust (*Melanoplus spretus*) and determining what could be done to check its ravages. The organization took place in March, with C. V. Riley, at St. Louis, Mo., as the chief, A. S. Packard the secretary, and Cyrus Thomas the disbursing agent. All three were eminent entomologists, and in the working out of the plans, each was assigned a certain territory to cover. Packard had western Wyoming, Utah, Idaho and the Pacific coast. He also visited Montana. In order to cover the assigned area, it was necessary to travel long distances by stage and otherwise, over much rough country, but it was a great opportunity to investigate the entomology of the west. The locust was finally vanquished through the cultivation of the regions where it was wont to breed and multiply, and today its migratory hordes are remembered only by the older settlers. The Commission, once established, broadened its activities, and dealt with many phases of economic entomology. Packard remained a member until 1882, and the fifth and last report of the Commission, published in 1890, was a bulky volume by him on the insects injurious to trees.

Packard was still a comparatively young man, not quite 40 years of age, when in 1878 he was elected Professor of Zoology and Geology at Brown University, Providence, R. I. A local paper, announcing the appointment, remarks that "The advent of Mr. Packard is not unlikely to form a turning point in the scientific history of this city and state." For the rest of his life Packard remained at Brown, finding ample opportunities for teaching and research. In 1893, Westwood having died, a desire was expressed that Packard should be appointed to the Hope Professorship of Entomology at Oxford, but the matter was not followed up, and Poulton received the appointment.

The 27 years at Brown University saw the maturest development of Packard's intellectual powers, and the widening of his already great influence on the younger generation. The salient events were comparatively few; occasional journeys abroad, the publication of books and memoirs, honors conferred by Universities and learned societies. In 1885 he made a journey to Mexico, accompanied by Professor Jenks. In 1886 he went to Florida and Cuba, at Havana meeting Poey, the eminent naturalist of that city. In 1889 he visited Europe for the second time, accompanied by his family. He found Dr. Dohrn now well established in his zoological station at Naples, and at Heidelburg renewed his acquaintance with Osten Sacken. At Wurzburg he visited Semper. He attended a meeting of the International Zoological Congress, and was elected one of the honorary presidents. In England he visited Sir John Lubbock, E. B. Poulton and others. In 1898 he was vice-president of the section of zoology of the American Association for the Advancement of Science. His vice-presidential address was on "A half century of evolution, with special reference to the effect of geological changes on animal life." In 1898 he also published his *Textbook of Entomology,* dealing with the anatomy, physiology, embryology and metamorphoses of insects. It is an entirely different book from the *Guide to the Study of Insects,* being primarily a college text for the special student, instead of a guide for the general entomologist and lover of nature.

In December, 1898, Packard crossed the Atlantic for the third time, accompanied by his daughter Frances. They visited the Mediterranean countries first, Gibraltar, Spain, Morocco, Algeria, Malta, Egypt, Palestine, Rhodes, Smyrna, Ephesus, Constantinople, Greece and Italy. They were the first Americans into Spain after the Cuban war. From Italy they went on to France, where much time was spent in looking up facts regarding the life of Lamarck; data to be used in the book, "Lamarck, the Founder of Evolution, his Life and Work," published in 1901. They finally returned by way of England, reaching Boston on September 22, 1899.

The fourth and last trip to Europe was in the summer and fall of 1900. In 1903 Packard visited Nova Scotia—his last excursion out of the United States. After the spring of 1904 his health began to fail, and on February 14, 1905, he died.

Reviewing Professor Packard's scientific work as a whole, we find that it has to do, (*A*) with the philosophy of nature, and the larger evolutionary processes, (*B*) with classification, (*C*) with the description of new forms of animal life, (*D*) with the popularization of natural science, and (*E*) with the economic applications of biological studies. In any one of these fields his work was sufficiently noteworthy to have given him a permanent position among American scientific men.

Packard was an ardent evolutionist, belonging to what was called the Neo-Lamarckian School, which he founded in connection with his friends Cope and Hyatt. To the support of their opinions these brilliant men brought a mass of observations; but today, in the light of modern experimental methods, the whole subject has taken on new aspects. It appears certain that we shall never return to Lamarckism, new or old; but the facts remain, still commanding attention and inviting investigation. The modern naturalist is at once more and less sure of his ground than the evolutionist of Packard's day. More sure, because supplied with a vast and growing mass of experimental data, which cannot be gainsaid. Less sure, because he is more aware of the complexity of natural processes and of the impossibility of finding a single formula to define the whole of evolution.

In his studies of the insects and crustacea, especially, Packard was a pioneer in classification. He perceived that the insect orders were more numerous than had been supposed, and tried to substitute a more natural arrangement than that in vogue. His work is now incorporated into the zoological system, and while many differences of opinion still exist, some at least of the Packardian group-names have come to stay.

Packard described as new over 50 genera and about 580 species of animals. Over 40 of the genera belong to the Lepidoptera; five are Crustacea. The species are distributed as follows: Aptera 41, Arachnida 34, Bryozoa 11, Crustacea 34, Diptera 7, Coccidæ 3, Mallophaga 14, Hymenoptera 101, Lepidoptera 308 (and 43 others now regarded as subspecies or varieties), Mollusca 4, Diplopoda 5, Pauropoda 1, Panorpidæ 1, Psocidæ 1, Orthoptera 3, Tunicata 2, Vermidea 5. Some of the Crustacea are fossil. Of the 580 species, at least 156 are now placed in the synonymy. Most of them are Lepidoptera, and a large proportion fall before names proposed by Walker and other authors whose descriptions were too poor for certain recognition. It is only because the types in Europe have been examined, that we are now in a position to interpret many of the older descriptions. Packard's descriptions differed greatly in quality. His later descriptions of moths in particular, were extremely full, with careful attention to structural details. Whenever his main purpose was taxonomic, his work was good; but he not unfrequently introduced new species very briefly, when using them as illustrations of some principle, or citing them in a general discussion. At such times, also, he seems to have been less careful than usual to ascertain that the species were really new. Thus of the 13 Lepidoptera named as new in the *Guide,* the majority are synonyms. These, however, are relatively minor matters, and the important thing is that in his monographic works, such as those on the Geometridæ and the Bombycoid moths, he presented a real morphology of the insects, in place of the short and artificial descriptions generally current.

It is characteristic of Packard's work, that he would publish an important paper on some group, and rarely or never return to it. Thus, for example, his paper on the fossorial wasps established him at the time as the leading authority on the subject, and made his name familiar to all subsequent generations of Hymenopterists. Yet, although many new wasps must have passed through his hands in later years, he paid no further attention to them. Probably this manner of working was partly accidental, or due to circumstances which could not be controlled, but it was also to some extent deliberate. It was wasteful of time, in the sense that after mastering a subject and accumulating the literature, it would have been much easier to continue along the same lines than to take up something new. It also deprived the author of the opportunity which a continuous worker has, of correcting his own mistakes. On the other hand, it is inconceivable that Packard could ever have become a narrow specialist, and the variety of subjects he studied gave him a power and mastery over the field of biology which he could not have acquired in any other way. In this he was like Darwin, who intensively studied barnacles, but after his monograph appeared, abandoned them and turned to other things.

In his later years, indeed, Packard was more consecutive, as witness his continued attention to cave faunæ and the Bombycoid moths. In the case of the Bombycoid moths, his last memoirs returned to the subject of his first taxonomic revision. The series of memoirs on the Bombycoid moths, published by the National Academy of Sciences, illustrate the trend of Packard's thought. Choosing a group with which he was familiar, and which had interested him since boyhood, he set out to describe it in such a manner as to illustrate biological principles in detail. He took the greatest pains to obtain, rear, and describe and figure the larvæ; not merely the mature larvæ, but all stages. As the work progressed, it expanded; and what began as a revision of the North American Bombycoids, developed into a consideration of those of the whole world. Could Packard have had another ten years of life and health, with sufficient opportunity to examine the European collections, the resulting treatment of the Bombycoids would have surpassed anything yet attempted. As it was, the last volume of the monograph, edited by another and finally published in 1914, necessarily remained incomplete as compared with what the author intended.

Although we have referred a number of times to the extent and variety of Packard's biological researches, there are some limitations which are rather surprising. In particular, his youthful enthusiasm for conchology bore almost no fruit in later years, at least of a direct kind. Mollusca are discussed, with original observations, in the papers on Labrador, but after that they are practically ignored. It may have been partly because Morse, Packard's colleague at Salem, was a specialist on mollusca and took charge of any that came to hand. Certainly Packard's pleasure and interest in the group must have continued; we find in the diary a record of the delight of finding the first nudibranch in the vicinity of Salem, and on his last European trip he collected snails. It is also somewhat surprising to find no original papers on botanical subjects. Packard studied plants as a young man, and throughout his life continued to take a keen interest in them. His journals contain frequent references to the flowers he saw. He certainly might have been a keen botanist had time and opportunity permitted.

Packard's contributions to popular science were numerous, but he never cheapened his subject to make it appeal to those who had no real sympathy with his aims. His object was to help beginners and amateurs to become naturalists, or at least to learn enough to appreciate some of the natural phenomena all around them. In all this he was very successful, and Dr. J. B. Smith of New Jersey said that "as a teacher through books he has taught more students than any other American entomologist." The writings on economic entomology were not clearly separated from the popular or semipopular papers just referred to; the one thing naturally graded into the other. The Reports of the Entomological Commission contains articles by Packard which are not so much directly economic, as affording a basis on which the economic investigations of others may stand.

Packard's scientific work brought him honors of various kinds, such as his election as foreign member of the Entomological and Linnean Societies of London. Bowdoin College conferred the Ph. D. and LL. D. upon him. Two genera of Lepidoptera (Packardia and Eupackardia), a genus of Hymenoptera (Packardiella), and at least 39 species and three varieties in various groups have been named after him. These include 22 Lepidoptera, 5 Hymenoptera, 2 Mollusca, 2 Crustacea, 2 Arachnida, and one each of Orthoptera, Heteroptera, Homoptera, Coleoptera, Collembola, Odonata, Myriapoda, Diptera, and Algæ.

Packard took great interest in his college teaching, and grudged no amount of trouble if he could assist those who were really interested in their work. In 1904 the class in anthropology presented him with a loving cup, the first that had ever been given at Brown. He was greatly surprised and pleased, saying when he came home, "I had no idea the students cared so much for me." At a memorial service held after his death, Mr. W. G. Meader spoke for the student body as follows: "We respected him, not only as an instructor, but because of his sterling character and genial disposition. He was fair-minded to a degree, never judging harshly. He was modest and retiring, yet he carried himself with a dignity that commanded our respect. He had a keen sense of wit that often lightened the class room. . . ."

From numerous letters and other documents it has been possible to compile a brief description of Professor Packard's personality, and the essential agreement of many independent witnesses gives us confidence in its accuracy. As a boy he was affectionate and playful, and already had a passion for collecting insects. As a young man, when visiting Labrador, he charmed every one there by his sincerity, kindly ways and enormous enthusiasm. Of all his personal characters, perhaps two stand out most strongly; his kindliness and courtesy, and his zeal for his work. He was strongly attached to home and family; social and sympathetic; yet not eager for "society" or social distinction. His defective palate somewhat interfered with his utterance, and probably tended at an early age to make him retiring and sensitive. Nevertheless, he spoke well, and had a good singing voice and a true ear. He was very fond of music, delighting in concerts and the theater. His temperament was emotional and artistic; two of his brothers were clever in drawing, and he might have developed in artistic lines had he not given his life to science. He delighted in good landscapes, and owned some himself. When traveling, he never failed to see the picture galleries. His artistic feeling was also manifested in his extreme delight in natural scenery, and his keen observation of beauty or picturesqueness of costume. His fad, when travelling, was buying oriental rugs and photographs of scenery and architecture. He even loved lace and bric-a-brac, and had a very keen eye for furniture and women's dress. Although he found the reading of poetry rather a burden when a boy, he assimilated the best of what he read, and liked to quote passages of Shakespeare. He also remembered his history well, and was eager to visit any spot of historic interest. When in Palestine, he listened to the stories of the guides, with faith that made the scriptural narrative live, and seemed to bring him into the presence of holy things. In his dealings with others, he was entirely honorable, and never forgot to give credit for assistance of any kind to younger men, in a day when this was by no means invariably the custom. It was difficult for him to imagine that others could be dishonorable in any way, and his trustful disposition once involved him in serious trouble and financial loss. Dr.

L. O. Howard remarks that when visiting Washington he always "treated the younger men with a very perfect courtesy and consideration." Unlike some professional biologists, he had a special regard for amateurs. Thus he became greatly interested in some weavers in the mills at Valley Falls. One of them came to see him, explaining that a number of them, coming from Lancashire, had brought specimens of rocks and insects, and had arranged them in a little room where they met in the evenings. Packard gladly went to give them assistance and advice, added to their collection, and was always ready to answer questions and solve difficulties.

He had an excellent sense of humor, which enlivened his teaching. Although unassuming and of a quiet disposition, he had a tremendous spirit when roused to just anger. He was notably courageous; after the war General Hyde said of him that he was a dare devil and knew no fear. Although his ordinary life called for no physical courage, he seems to have enjoyed situations of danger, and of all his experiences he liked best to tell of his ride through Lee's army, immediately after the surrender. He also did not hesitate to travel in Spain immediately after our war with that country.

A little personal peculiarity, in which he resembled the English entomologist Westwood, was that of economizing paper. He would write his notes on any scraps of envelopes, wrapping paper, etc., which were available, and this sometimes made his writings difficult to edit when they were transmitted to Washington for publication. He was a very keen collector of insects, and whether in America or abroad, he always carried collecting bottles. His enthusiasm never waned, and he never became a purely indoor and laboratory naturalist.

His personal appearance is thus described by one who knew him intimately: His forehead was like Darwin's bust, rather low immediately above his eyebrows, then rising again high and broad. His head was broad above the ears. The play of expression in his gray eyes varied from a very sad and pathetic one to sparkling humor. He was tall, very slight, quick and nervous. He usually sprang up-stairs, three steps at a time. He had small and shapely hands and feet. He dressed immaculately, and carried himself gracefully; he liked to dance about in playing with his children.

Regarding Packard's life as a whole, we see a man who was spurred forward by internal rather than external stimuli. He did not work primarily for such rewards as the world might give, and when these came he was usually surprised. Humble concerning his personal achievement, he had unbounded faith in the cause he served, and unlimited zeal in the service. He was a good and faithful soldier in the army of science, and as such was captain to many more than he ever knew. His influence remains, and will long continue a factor in the scientific life of America.

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[*] In 1887 the U. S. Department of Agriculture published Division of Entomology Bulletin 16, The Entomological Writings of Dr. Alpheus Spring Packard, by Samuel Henshaw. This lists 339 titles, and has been fully utilized in preparing the present bibliography. I have also had access to a list of additional titles, either not entomological or subsequent to Henshaw's work, prepared by Dr. Packard himself. Still other titles have been obtained in various ways, many from the Zoölogical Record. Although this bibliography is long, no doubt some papers have been overlooked, but probably none of first-class importance.

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    Chapter 10. The embryological development of the locust, pp. 263-285.
    Chapter 11. The systematic position of the Orthoptera in relation to the other orders of insects, pp. 286-345.
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Lewis Boss

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1846-1912

BY

BENJAMIN BOSS

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LEWIS BOSS

1846-1912

BY BENJAMIN BOSS

Lewis Boss, astronomer, was born at Providence, R. I., on October 26, 1846, the son of Samuel P. and Lucinda (Joslin) Boss. He died at Albany, N. Y., on October 5, 1912. Though there is no record of scientific forebears, nor any trace of scientific tastes in his brothers and sisters, Lewis Boss evidenced a strong inclination toward a scientific career even in early youth, as was manifested by his keen power of observation and by his desire to prove for himself truths generally accepted without question by the great majority. The habit of accurate representation, so necessary to the scientific man, is attributable to his father and mother, descendants of old New England families.

After a preparatory education at boarding school he entered Dartmouth College in 1866, graduating in 1870. Though his college training was classical, he showed a marked preference for scientific subjects, and this tendency was encouraged by Prof. Charles A. Young, who, at the time, held the chair of mathematics and astronomy at Dartmouth College. Through frequent visits to the college observatory, Professor Boss became acquainted with the manipulation of astronomical instruments and with the methods employed in the reduction of observations.

It was during his leisure hours, and purely as a matter of interest, that he undertook an exhaustive survey of the college grounds. In later years Professor Boss learned that this survey had served as an ideal of attainment for the students of following classes.

At the end of his college course he accepted a clerical position in the Census Office at Washington, and later moved to the Land Office. But he had not renounced the idea of a scientific career. Whenever opportunity offered he visited the

Naval Observatory. There he borrowed a sextant and chronometer and commenced a series of observations which were carefully recorded and reduced. He also investigated the errors of his instrument with great thoroughness. The results, which were of no particular scientific value, were far-reaching.

When in 1872 the U. S. Northern Boundary Commission undertook the survey of the 49th parallel boundary line between Canada and the United States, extending from the Lake of the Woods westward to the Rocky Mountains, application was made to the Naval Observatory for the services of an astronomer to be employed as civilian astronomer on the coming expedition. As there was no one available at the observatory, the commission was advised to examine Professor Boss's work. The neatly kept record of sextant observations, as well as the excellency of the observations, secured him the appointment.

On December 30, 1871, Professor Boss had married Miss Helen M. Hutchinson, of Washington, who, though a bride, consented to the separation, for a large part of several years, necessitated by the new appointment. This spirit of a willing sacrifice of her personal feelings to promote her husband's scientific needs was characteristic of her whole married life and undoubtedly contributed in large measure to her husband's success.

The years of the boundary survey were years of great unrest among the Indians. The expeditions were heavily guarded, and thus escaped attack, though several serious situations arose when it became necessary to arrange for proper defense. Only a year after the last expedition, General Custer and his force were annihilated by the same Indians who on one occasion had threatened to attack the survey party. Many tribulations resulted from the roughness of the virgin territory over which the expedition passed.

It was Professor Boss's duty to first locate the working camps by sextant observations, and then to determine accurate latitudes with the zenith telescope. The survey parties followed, setting boundary marks with reference to the latitude stations.

Not long after the enterprise started Professor Boss, in deriving the latitudes, saw the need of revising the positions of the published declinations of standard stars. Consequently he undertook to treat the observed declinations of these stars in a manner which should free them, as nearly as possible, from all systematic corrections due to imperfections in the instruments used or to imperfect reductions, finally uniting them in a homogeneous system. The computations for the catalogue were largely accomplished at night, after a hard day in the field, under very adverse conditions. His perseverance and insatiable appetite for hard work, as evidenced in this undertaking, were most characteristic of the man. But, despite his diligence, the catalogue of standard declinations was incomplete when the boundary survey terminated in 1876.

Fortunately the work was not interrupted; for the offer of the directorship of the Dudley Observatory at Albany, N. Y., by its board of trustees, followed the closing of the survey and enabled Professor Boss to complete the work of standardizing declinations.

But the long strain to which he had subjected himself told in the end, and a general breakdown resulted. Perhaps the worst phase of this was the inability to use his eyes. Undaunted, he enlisted the services of his wife, to whom he dictated his thoughts; and thus with her aid the preparation of the introduction to the catalogue was accomplished. The manuscript was reread to him, was corrected and amended where necessary, and finally was sent to the printer.

The completed catalogue of standard declinations was published in 1878 as an appendix to the Report of the U. S. Northern Boundary Commission. Professor Newcomb in his Spherical Astronomy remarked: "The declinations were so thoroughly worked up by Boss that the continued use of the A. G. system of declinations until 1900 is to be regarded as unfortunate." The system was adopted in the American Ephemeris 1883 to 1899. Its publication gave Professor Boss immediate recognition at home and abroad.

A short rest was sufficient to restore the use of his eyes and his bodily strength, so that he was able to accept the invitation of the U. S. Government to join the total solar eclipse expedition at West Las Animas, Colorado, in 1878. The results are published in the Government Report of the Eclipse. In the report the significant curved rays in the corona, near the poles of the sun, were recognized and described.

Professor Boss accepted the directorship of the Dudley Observatory at the lowest ebb in its history. The new director was chosen in hopes that something might be done to place the institution on the astronomical map. Partly in order to arouse more popular interest in the institution, and partly to fill in during the preparation of a more extensive program, Professor Boss began cometary observations.

But an invitation to join the work of the Astronomische Gesellschaft curtailed the comet work.

In 1878, after correspondence with the Zone-Commission of the Astronomische Gesellschaft, Professor Boss undertook the observation of one of the zones into which the northern sky had been partitioned for a comprehensive scheme of position-measurements, under international co-operation. The project was to secure an accurate determination of position, in duplicate, for every star in the northern sky as bright as the ninth magnitude. Such a star is about one twenty-fifth the brightness of the faintest star visible to the unassisted eye. The sky was divided into eighteen parts, and that assumed by Professor Boss embraced the zone from one to four degrees north of the celestial equator.

When the zone project was inaugurated, there had been vain hopes that all the observations could be begun and completed at approximately the same time. Unfortunately, among the many participating observatories some were unable to complete their allotted portions of the work, so that a few zones had to be reassigned. It was one of the abandoned zones which Professor Boss agreed to observe. His late start made it all the more necessary to push the observations to completion in order to comply with the general scheme.

With customary zeal, though with little assistance, Professor Boss attacked the observations and reductions so vigorously that the observations were completed in about three years from the start; the catalogue was essentially completed in 1886, and was presented for publication in 1887, the first zone to be completed. Because of the slow process of printing, the catalogue was not ready for distribution until 1890. The observations were not only quickly completed, but proved very accurate, due to the infinite care taken that every source of error should be investigated and eliminated. Altogether there were about twenty thousand observations taken of 8,241 stars.

This was the first astronomical publication containing an extensive contribution of results to emanate from the scientific exertions of the Dudley Observatory.

The successful completion of the work was not solely due to his scientific efforts. The observatory was at a low ebb in its financial history. Consequently, in order to obtain the requisite support for the undertaking, he devised ways and means of procuring additional revenue. This was accomplished partly by raising subscriptions amounting to about $2,700, partly by furnishing time to the city of Albany, and partly by turning into the treasury of the institution his salary as Superintendent of Weights and Measures of the State of New York, a position to which he was appointed in 1883 and which he held continuously until 1906.

The cometary work which Professor Boss wove into his regular work stimulated him to compete for and win a prize presented by Mr. H. H. Warner, of Rochester, for the best essay on the physical nature of comets. It evidenced his interest in the physical development of the science. In later years he often complained that the demands of astrometry upon his time did not allow him the desired amount of leisure to become more familiar with astrophysical problems, though in a spirit of fun he was wont to chaff his astrophysical friends on the general uselessness of their pretty pictures, as he termed their observational photographs.

From September, 1882, to February, 1883, he was occupied with the duty of observing the transit of Venus, December 1882. For this purpose he had been placed in charge of the Government party sent to Santiago, Chile, to observe the transit. The weather was clear on the day of the transit, and the observations were entirely successful. More than 200 photographs of Venus in transit were obtained. Curiously enough, neither Professor Boss nor his scientific assistant, Mr. Miles Rock, were at all familiar with photography, while the two professional photographers had no experience with celestial photography.

From the very day of landing the Chilian Government extended the greatest care and courtesy to Professor Boss as a representative of the U. S. Government. His equipment was transported free of charge and his party were tendered a private car from Valparaiso to Santiago. The President of Chile placed his box at the theater at the disposal of Professor Boss, and the leading citizens of the capital vied with each other in providing hospitable entertainment. Nevertheless he felt constrained to refuse all entertainment until after the successful conclusion of his enterprise, when he gave himself over to a brilliant train of social functions. In return for the hospitality he had accepted as a representative of the U. S. Government, he gave an elaborate banquet. What was his dismay when on his return to Washington this item was stricken from his expense accounts. At length the matter was amicably adjusted by nominally continuing his services until sufficient salary had accumulated to defray the expenses of the banquet.

During the period of comparative inactivity following upon the completion of the zone catalogue, Professor Boss accepted the position of editor and manager of a daily newspaper, the Albany *Morning Express,* which had sadly run down. Under the stimulus and good business judgment of the new manager, the paper was rebuilt. His editorials were widely read and quoted, especially his editorial on the death of General Grant, which was favorably commented upon by the press of the entire country.

At about the same period he took an active part in politics. He strongly espoused the candidacy of James G. Blaine for President in the campaign of 1884, when Grover Cleveland was elected, though his personal relationship to Mr. Cleveland was most friendly. He also devoted much time and energy to the senatorial campaign of William M. Evarts. Senator Evarts attributed much of the success of his campaign to the efforts of Professor Boss.

The city of Albany celebrated the bicentennial of the city's incorporation in 1886, with much pomp and ceremony. Professor Boss was one of the original committee of twenty-five appointed by the mayor to carry out the plans of the celebration. He was chairman of the Committee on Historical Pageant and was a member of three other committees. His unremitting labor and great enthusiasm stimulated the whole organization.

The cometary observations, which were taken in a somewhat desultory manner during the prosecution of the zone work, figured notably during the ensuing years and continued to absorb a large part of the labors of the observatory until 1895. The Dudley Observatory became a recognized center for securing early information in relation to comets, to be diffused in this country and in Europe by a bureau of astronomical telegrams. For these years there was rarely a newly discovered comet for which the first orbit was not computed at the Dudley Observatory. These first orbits were usually supplemented by revised calculations made at the observatory and printed in the astronomical periodicals.

In March, 1882, a new comet was discovered by Mr. Charles S. Wells, an assistant of Professor Boss. This comet turned out to be of unusual interest. It was visible for a long time, and was the first to give unmistakable evidence of the presence of sodium in its composition, therein proving that comets are not constituted solely of a narrowly restricted number of purely gaseous elements. Professor Boss prepared a special catalogue of about 500 stars to be used in comparing the positions of this comet.

In the year 1887 and again in 1889 he visited Europe, partly to accompany his family, who remained abroad during that period, and partly to visit European observatories, where he learned much regarding the future plans of astronomers. This enabled him to avoid unnecessary duplication of results in laying out a new program of work.

It will be surprising to many of his contemporaries to learn that the ideas leading to his later efforts had assumed concrete form as early as 1887, and were an outgrowth of the zone work. When the results of measurements upon the positions of about 8,000 telescopic stars had become known, a detailed and critical comparison of these with observations made in the past showed that the faint, telescopic stars participated in the parallactic effects of the solar motion in space to a degree before unsuspected. With reference to the great mass of faint, telescopic stars a general impression has prevailed that their motions were really so small that no measurable tendencies to systematic motion could be detected through a comparison of the oldest with the latest observations of such stars. Professor Boss's investigations, 1887-9, cleared up that point. They showed that the average star of the ninth magnitude is really much nearer to us than had been generally supposed, although this conclusion was accepted with marked reluctance at the time.

As the zone work neared completion he had already begun preliminary investigations in relation to an undertaking of much more ambitious scope than any in the previous history of the observatory.

The principal feature of the work was to be a critical and independent inquiry in regard to the motions of certain of the so-called fixed stars. The investigation at the time was of fresh interest, since on account of the forbidding character of the great labor involved, very little had been done by astronomers. It was known that certain stars are endowed with motions far exceeding in velocity any which are known in the solar system, but practically nothing was known in regard to the laws of these motions; and since Argelander's time no astronomer had undertaken to gather even the existing evidence in regard to them, which is scattered in hundreds of bulky volumes issued from time to time by the leading observatories. Professor Boss thought that the evidence, which was mostly of a fragmentary nature, should be collated and supplemented by a special investigation through the most refined and searching observation of which astronomical science was capable. Using Professor Boss's words: "Growing out of this problem are numerous others relating to the structure of the universe of worlds which lie beyond the solar system. Upon these problems it is proposed to bring to bear all the light which is afforded by the combined labors of astronomers during the last hundred and fifty years, which constitutes the period of exact researches relating to the stars, and to add as much as may be found practicable with the resources of the Dudley

Observatory. A successful completion of this task as a whole is to be hoped for, but cannot, of course, be promised."

Two great obstacles presented themselves to block the way of progress: First, the considerable financial backing needed for such a large undertaking, and, secondly, the need of better observing conditions than could be secured at the observatory. Unsurmountable as these obstacles must seem to the dispassionate observer, Professor Boss attacked them with characteristic energy and confidence.

The original location of the Dudley Observatory, in close proximity to the four tracks of the New York Central Railroad, proved decidedly inconsistent with the higher uses of astronomical instruments, because of the jar and smoke to which they were subjected. In addition, the room in which the meridian circle telescope was mounted was entirely unsuited for delicate observations on account of its thick masonry walls and its proximity to the main building.

For these and many other reasons Professor Boss suddenly determined, in 1891, to attempt to negotiate provisional arrangements with the city authorities by which an exchange of property between the city of Albany and the observatory might be effected. The proposition was that the city should cede to the observatory a tract of land in the western part of the city and the sum of $15,000 in exchange for the real estate then owned by the observatory.

He approached the trustees of the institution with his proposition and earnestly recommended that efforts be made to secure the removal on the terms proposed. The arrangement, however, could not be consummated without contributions from private sources.

Fortunately, in the spring of 1892, Professor Boss, after a number of conferences with Miss Catherine W. Bruce, of New York city, received from her an offer of $25,000 to increase the permanent endowment of the Dudley Observatory, provided the proposed exchange of property with the city be effected and additional funds be subscribed by other friends of the observatory sufficient to defray the cost of re-establishing the observatory on the new site.

Contributions in excess of the required amount were collected in a surprisingly short interval. Mr. Robert C. Pruyn and Mr. Charles L. Pruyn donated a new equatorial telescope, while Messrs. Dudley, Frederic P., and John Olcott provided means for modernizing the Olcott meridian circle, and for re-establishing it upon the new site in a building of special construction admirably adapted to its purpose. Miss Catherine Bruce added $10,000 to her original donations, in view of the spontaneous reply of the citizens of Albany to meet the requirements of her previous donation.

On November 8, 1893, the observatory was formally opened for inspection, and in honor of the occasion the National Academy of Sciences and many prominent scientific and educational men were present.

Thus the Dudley Observatory, well equipped for its special work, found itself prepared in 1894 to enter upon a renewed career of astronomical activity under greatly improved conditions.

During the interval made necessary for the purpose of arranging a new campaign, the observatory again became active in the observation of comets and minor planets and in computations relating to them. The minute instrumental errors of the telescope to be used were also thoroughly investigated during this period.

Since the financial condition of the observatory did not warrant as extensive a plan of observation as had gradually been crystallizing, Professor Boss, practical to the extreme, was governed by two rules: first, that the program of work should be organized in distinct, successive steps, in such a manner that each should contribute to the problem sufficient in value to warrant the undertaking of it in and for itself; second, that he should not in advance promise to accomplish more than one of these steps. In this way he hoped to escape the charge of undertaking what some might consider manifestly too great a task for his comparatively small resources; and, on the other hand, he had the advantage of working along the lines of a systematic, connected, and cumulative program with all the incentive and inspiration resulting from a lofty aim.

As a preliminary step in this program he began observations upon stars, suspected of sensible motion, in the belt of sky between 20° and 41° south of the equator, with a view to the more accurate determination of their motions. The field chosen was one practically inaccessible to the principal observatories of Europe, owing to their more northerly latitude. While the computations in the preparation of the catalogue were for the most part finished within a few years after the last observations were taken, the catalogue of 8,276 stars has not yet been published, though it is now (in 1917) going through the press.

Another item contributed toward the contemplated whole was completed in 1898. It dealt with the positions and motions of 289 of the principal stars of the southern hemisphere, and was followed in 1903 with a catalogue giving the positions and motions of 627 principal standard stars. This catalogue was derived through a thorough and painstaking treatment of the systematic errors of catalogues, the corrections of the catalogues for these errors, and the consequent combination of the whole material in a fundamental system.

Meanwhile, the results of many years of study relating to the problems of proper-motion had led Professor Boss to the formation of a manuscript card catalogue comprising about 26,000 stars, selected either because of known or suspected proper-motion. It was his intention to secure observations of all of these stars, to form a catalogue from the observed positions, and then to compare these modern observations with those taken at intervals in the past by many other observers. From a comparison between the ancient and modern positions of a star, its precise direction of motion and the amount of that motion could be determined.

Though appropriations from the Bache Fund of the National Academy of Sciences, together with generous private contributions by the trustees of the Dudley Observatory, had financed his plans thus far, the undertaking of so stupendous a project as the observation and accurate determination of the positions and proper-motions of 26,000 stars would have been impossible had not the Carnegie Institution, in 1903, decided to lend financial aid to the undertaking.

The great demand for preliminary results for some of the brighter stars led to the preparation of a catalogue of 4,300 of the brighter stars whose positions and proper-motions were designed in the first place as a foundation for an exact determination of precession and solar motion, and in the second place as a normal of reference in relation to the stars visible to the unassisted eye. This catalogue in the end grew to include 6,188 stars. The work was, essentially, a collection and mathematical discussion of all the meridian observations of precision that had been made upon the stars visible to the naked eye during the entire history of astronomy, in order to determine the relative motions of each, as well as their positions—past, present, and future—as exactly as they could be calculated from existing measurements.

In this catalogue, entitled the "Preliminary General Catalogue of 6,188 Stars," there is epitomized for each star all that is known of its history as a moving body. It is therefore designed to be and has proved to be a useful work of reference. The catalogue was not completed and printed until 1910.

Even with the aid furnished by the Carnegie Institution of Washington, dating from 1903, and a donation of $25,000 to the Dudley Observatory by Mr. Frederic P. Olcott, the main project seemed too large to accomplish.

It was therefore an immense relief to Professor Boss to receive news in 1906 of the establishment by the Carnegie Institution of Washington of a Department of Meridian Astrometry, whose sole aim was the prosecution of his work under his direction.

In preparation for the observational program the Olcott Meridian Circle was renovated, chiefly through the substitution of newly graduated circles, and the errors of division of the regraduated circles were thoroughly investigated, as were all other instrumental corrections.

In 1907 the observations of the big list of 26,000 stars were begun, and for two years this work was continued at Albany.

As the completion of the plan necessitated the observation of those stars in the southern hemisphere not accessible from Albany, an expedition was launched on August 20, 1908, to establish an observatory in the southern hemisphere. The new branch observatory was located at San Luis, Argentina, about 500 miles west of Buenos Aires, on the lower plateau of the Andes. The expedition was equipped with the same instruments used at Albany and was manned principally by the same staff employed at Albany. Professor R. H. Tucker, of the Lick Observatory, was placed in charge of the station. The expedition was so well planned that within two days after the arrival in San Luis building operations were under way.

Messrs. Tucker and Varnum were left in San Luis to carry on the building operations, and Professor Boss sailed from Buenos Aires October 10, 1908, on the return trip. He was shipwrecked on a dark night at the southern end of San Sebastião Island. The consequent wetting, exposure, and want of food for two days left him apparently unaffected.

With his usual thoroughness he made necessary instrumental investigations before dismounting the equipment at Albany prior to shipment to San Luis. Undaunted by the shipwreck experienced on the recent homeward voyage, he sailed with the second section of the expedition on January 20, 1909, and remained at San Luis until the instruments were in working order and their errors once more determined as a test of their escape from injury. Satisfied that no sensible harm had befallen the equipment during transportation, he sailed for Europe to attend the meetings of the Astrographic Chart Congress at Paris in 1909.

The staff at the branch observatory at San Luis commenced observing in March, 1909, at the unprecedented rate of about 60,000 observations per year. Upon the completion of the work, in January, 1911, the instruments were promptly dismounted, carefully packed, and shipped to Albany, where they arrived in April, 1911. Subsequent investigation proved that the equipment had once more escaped injury in transportation. It was again set up in Albany and employed upon observation of the stars accessible from that latitude.

Meanwhile, Professor Boss had attended the Astrographic Congress at Paris, and with part of his family had made an extensive tour of Europe, visiting the principal observatories. Upon his return to Albany and in connection with consultations with other members of the committee on proposed fundamental observations desired by the Paris Congress of April, 1909, he prepared a "List of 1,059 Standard Stars for 1910."

The purpose of the catalogue was to furnish a list of standard stars homogeneous in character, whose places and proper-motions could be materially strengthened by further observation.

The Preliminary General Catalogue already referred to was published in 1910. It was expected that its chief value would be found in throwing a clearer light upon the structure and operations of the universe of stars, including the motion of the sun in space. Partly before its appearance and partly after that time, a thorough study was made of the solar motion and those problems related to such a discussion. These investigations were published in a series of papers in the *Astronomical Journal.* The last part of the series deals with the systematic motions of the stars arranged according to spectral types, and as our present ideas would seem to indicate that change of spectral type takes place as a result of a change in the age of the stars, a treatment of the motions of stars arranged according to type corresponds to a treatment of their motions with reference to the age of the stars. This investigation yielded many interesting results.

It confirmed the investigations of Prof. W. W. Campbell derived from the radial velocities of the stars, that with the progression of spectral types the star's motion is apparently accelerated, very rapidly at first, and then gradually, until in the later types the average speed of the stars is practically uniform.

It was demonstrated that the actual linear velocity of the class of stars designated A rapidly increases with the distance of the star from the Milky Way.

The paper in general was a remarkable treatise on some of the peculiarities in the structure of the sidereal universe and an admirable justification of the stand taken by Professor Boss that studies based upon the old astronomy were destined to throw as much light upon the problems of the sidereal structure as those based upon the new astronomy. It was also a justification of the task he had been foresighted enough to undertake.

A further paper dealing with the direction and relative distribution of stellar velocities has not been published. It indicates that while the distribution of the velocities in direction seems to be virtually at random, the linear velocities in the general direction of the constellation Orion bear to the linear velocities at right angles to this direction the ratio of 7 to 4.

Professor Boss contributed many small articles in addition to his larger publications. While ordinarily his work was of the non-spectacular type, his discovery of a large stream of stars in the constellation Taurus excited universal attention. The members of this group were found to be moving through space at a uniform velocity in practically parallel paths.

Late in the year 1909 the editor of the *Astronomical Journal*, Dr. S. C. Chandler, a warm personal friend of Professor Boss, transferred the editorship of the paper to him. The *Astronomical Journal* was founded by Dr. B. A. Gould in 1856, to serve as a scientific organ of astronomy in the United States. Professor Boss manifested a keen interest in the publication, not only because of its relation to American astrometry, but because it became a matter of pride with him to restore to its original flourishing condition a journal supported and successively edited by two intimate astronomical associates.

Professor Boss was an extremely hard and tireless worker, whether in the interest of his chosen work or when engaged upon outside projects. Every body of men with whom he was associated became aware of the force of his personality and his keenness of vision. He had a perfect fatality in putting his finger on the weak point of any proposition. On the other hand his constructive reasoning proved of immense value to his associates. These characteristics bore an important relation to his work and to his attitude toward the members of his staff; for he was never content to implicitly trust his associates with the conduct of any department of his work, but must personally supervise even the small details, though it increased his burdens many fold. Thus he held in his fingers all the loose ends and wove them into a carefully thought-out pattern.

Naturally such strict supervision was not calculated to bring out the originality of his associates, but they did acquire an insight into the problems presented and an enthusiasm for the work which materially aided its accomplishment. While intolerant of the sluggard or the failure, he was very patient with those who were struggling for a footing. He was at his best in the company of keen minds. To others he was quite unresponsive.

Commenting editorially on the death of Professor Boss, The Albany *Evening Journal* of October 5, 1912, said in part: "Though devoted to his science, he did not live aloof from his fellow-citizens, but always took a keen interest in matters affecting the welfare of the city. Being of thoroughly kindly disposition, he was beloved as well as esteemed by all who in the course of many years had come to know him. He became great as a scientist; he was good as a man. He will be sadly missed by those who enjoyed his friendship, and those who read of his doings that won him fame will regret that henceforth his name will be only a memory. To the world of science and to this community in particular his death is a loss that will be keenly felt."

Toward the end of his career the disregard of his physical self told, and gradually the exhausted system grew weaker and weaker, though the mental activity continued. About two years before his death his general condition became more serious. A series of attacks of varied nature assailed him, yet through it all he clung to the hope that he would soon recover sufficiently to complete the great undertaking which practically amounted to a life's effort.

While it was not granted to him to bring this work to completion, it is pleasant to recall that he carried it far enough to obtain a very fair idea of the benefits to be derived from it, and to foresee the trend of astronomical research for the coming century or two. He was a pioneer in the new developments.

Professor Boss received the gold medal of the Royal Astronomical Society, London, in 1905, and the Lalande prize of the Paris Academy of Sciences in 1911. He was elected a member of the National Academy of Sciences, the American Philosophical Society, the Astronomische Gesellschaft, and the American Academy of Arts and Sciences; foreign associate of the Royal Astronomical Society; corresponding member of the British Association for the Advancement of Science, the Prussian Academy, and the St. Petersburg Academy. He received the honorary degree of A. M., Dartmouth, 1877;

LL. D., Union, 1902; Sc. D., Syracuse, 1910; Sc. D., Dartmouth, 1912.

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Charles S. Minot

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OF

CHARLES SEDGWICK MINOT

1852-1914

BY

EDWARD S. MORSE

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CHARLES SEDGWICK MINOT.

1852-1914

BY EDWARD S. MORSE

To get a true grasp of the character and ability of this man and to appreciate the attainments of this indefatigable worker, one may read the many encomiums and memorial addresses by eminent anatomists and educators, or read his published contributions to science, of which there are a great number. In an address before the American Association of Anatomists, Dr. Frederic T. Lewis declared that Dr. Minot was "by common consent the leading American anatomist." Dr. Lewis, in this address, gives a brief review of his genealogy. On both sides he finds talented men and women, distinguished for their scholarship, occupying high places in public service.

Dr. Minot represented the fifth generation from Jonathan Edwards, whom the historian Fiske regarded as "one of the wonders of the world, probably the greatest intelligence that the western world has yet seen." If one compares the portrait of Dr. Minot with that of Jonathan Edwards, certain resemblances are recognized. "Holmes describes Edwards as possessing a high forehead, a calm, steady eye, and a small, rather prim, mouth; no reference is made to the rather long, well-modeled nose, which is much like that of his descendant; . . . but whether or not this facial resemblance is objective, these two relatives are alike in possessing the inquiring, analytical mind of the naturalist."

Rev. Theodore Dwight Woolsey, past president of Yale University, read an address on Jonathan Edwards at the 200th anniversary of Edwards' birth, and says of him: "His intense devotion to theological problems on such questions as The Nature of Virtue, The End for which God Created the World, Original Sin, etc., suggests the devotion of Dr. Minot to problems in some respects of a like nature, such as Is Man the Highest Animal? Death and Individuality, Researches on Growth and Death, Organization and Death." Dr. Woolsey termed Edwards' essays as scientific theology. Dr. Lewis says Dr. Minot's early papers on insects may be compared with Edwards' remarkable paper on Balloon Spiders, believed to have been written when he was not more than twelve years old. He gives a brief extract of this paper, which is rigidly correct, and says: "These beautifully accurate observations and experiments, recorded with sketches, amply justified Dr. Packard's opinion that in another age and under other training Edwards might have been a naturalist of a high order."

Dr. Minot's father owned a large estate in West Roxbury. For four miles toward Dedham the woods were almost continuous and hardly a house was seen. His father says, "My children's love of nature was developed by their mother's tastes." Henry, who was younger than Charles, did not care to shoot or collect birds, but he studied them with great avidity, and at seventeen had completed his well-known book, entitled "Land Birds and Game Birds of New England."

Dr. Councilman, in his memoir of Dr. Minot, describing the region he roamed over, forest and dale, much of it included in the Metropolitan Park system, says: "In such surroundings the boy grew up and early acquired the love of nature, the capacity of seeing, and the scientific curiosity to find out the meaning of things he saw, which distinguished the life of the man. He was a member of a large and well-known family, with inherited wealth and distinguished in useful service." Dr. John Bremer's memoir in the *Harvard Graduates' Magazine* says his scientific attainments were fittingly acknowledged by honorary degrees at home and abroad and by the presidency of several scientific societies. Perhaps his crowning pleasure was when he was chosen as the exchange professor from Harvard to the University of Berlin.

Dr. Councilman says "He was in all respects an admirable teacher; as a lecturer, simple and clear, often enlivening his subjects by shafts of clean humor, and in the laboratory stimulating, always insisting that the students should cultivate the faculties of independent observation and judgment.

His laboratory was always orderly, giving one entering it the impression given by a well-ordered household."

Mr. Bremer says: "It was Dr. Minot's firm conviction that every hard worker, but especially every scientific investigator, should have a most engrossing hobby to supply a forcible restraint to his brain activity. His own hobby was his garden at Readville, where he turned his attention to growing rare varieties of peonies with great success. It was his delight to invite his neighbors on a certain day in spring to see with him the result of his care and skill."

Though we had been friends for nearly fifty years, I shall always remember my first meeting him. He introduced the subject of brachiopods by some inquiry and in our conversation expressed the conviction that I was right in my contention regarding the annelidian affinities of these creatures. He seemed so sure in offering these opinions and appeared so young that I was led to question him about the subject and found that he had a comprehensive view of the anatomy and embryology of the mollusks and annelids and appreciated the homologies I had made. It was very agreeable to me, for my views had been stubbornly condemned by malacologists.

At our Naturalists' Club dinners he was always bright and witty, with good stories, though preserving a self-respecting attitude. His story of a feline encounter rendered into English was inimitable. In addressing meetings as presiding officer or in communicating scientific papers, his attitude was one of seriousness and dignity. His words were carefully selected and one realized how keenly his mind was concentrated on the subject. He held his head fixed, though his eyes would glance aside at times. He was always courteous in his manner, though often absorbed in thought. His walk was alert and in a straight line; his attitude was always that of a thoughtful student.

Always a great reader, he began September first, 1870, at the age of eighteen, to record the titles of books read by him in monthly periods. These books were by the best authorities in literature, science, art and romance, classical and modern. This record ceased for a time in September, 1883, with 348 titles, many of these representing two and three volumes. It is an interesting fact that when he began the reading of German books their titles were always recorded in German script. He began a new list in February, 1885, and ended in June, 1891, with a record of 145 titles. His first three books recorded were "Das Abentener des Neujahrsnach," by Zschokke; "William Tell," by Schiller, and "The Luck of Roaring Camp," by Bret Harte. His last three books recorded in June, 1891, were "Histoire de Charles XII," by Voltaire; "Twenty Years After," by Alexander Dumas, and "Portraits Litteraires," three volumes, by Ste. Beuve.

His first communication, published when he was sixteen years old, was his discovery that a butterfly, *Chrysophanus americana,* had three broods, the first one appearing early in May and the third the last of August. The insects of the first brood differ from those of the other two in wanting the row of red spots on the under side of the secondaries. His second paper, published in 1869, was upon the discovery of the male, never before seen, of a certain species of butterfly. In this paper he adds that from an examination of twenty specimens of Hesperia regarded as two distinct species he was convinced that they belonged to the same species. Within five months he described three new species of Geometridæ.

His notes on the flight of New England butterflies are interesting as showing his keenness of observation. He actually classifies them by their flight, making three main divisions: in one the flight was sweeping, long sailing; in another, not sailing and shorter than the first group, more or less undulating. In a third group the flight was jerky, generally short. Then he detects certain groups when disturbed return after a short interval to the same spot.

In his Lowell lectures on the "Problem of Life, Growth, and Death," afterwards published in six consecutive numbers of the *Popular Science Monthly,* one derives many items of interest outside the orderly development of the subject. Thus, in the briefest and clearest manner, though somewhat satirical at times, we have a sketch of the various ideas held regarding life units, beginning with Darwin's theory of pan-genesis, which is the only one, Minot says, that seems to him "intellectually entirely respectable." With Darwin's gemmules we have in turn a rapid survey of the physiological units of Herbert Spencer, Haeckel's Plastidules, to which, he says, Haeckel gave the charming alliterative title of "perigenesis of the plastidules," and adds: "The rhythm of it must appeal to you all, though the hypothesis had better be forgotten." So in turn is given Nageli's Idioplasma-Theilchen; Weisner's Plasomes; Whitman's idiosomes, Haacke's gemmules; Allmann's granuli; Nussbaum's theory of geminal continuity, which Weismann elaborated into the smallest of life units, a group of these being determinants, which grouped together formed ids, and these in turn formed idants. Minot says, with sly humor, "If you want to accept any theory of life units, I advise you to accept that of Weismann, for it offers a large range for the imagination and has a much more formidable number of terms than any other."

Dr. Minot originated a number of technical terms in his papers on anatomy and embryology, and in his presidential address before the American Association of Anatomists he gave in a foot-note a brief list of new terms he has introduced in the address which he modestly recommends for adoption. These are cytogenic glands, cytomorphosis, false glands, lymphæum, mesepatium, phrenic area, and trophoderm.

In his studies Dr. Minot often found himself at variance with other investigators and he criticised fearlessly, even the highest authorities, and his objections were often framed in emphatic words. The exalted reputation of the author in no way modified the emphasis of his criticism. Huxley, Haeckel, Weismann, and others were combatted thus in an address before the New York Pathological Society on the Embryological Basis of Pathology. When Roux advanced the mosaic hypothesis, he said: "It is fortunate for our comprehension of pathological processes that we are already able to say that Roux's theory is erroneous."

Some of his protests bordered on the dogmatic, and from Dr. Lewis's memoirs we quote the following: "In taking leave of psychical research, Dr. Minot published a characteristic statement which involved him in amusing consequences. He said: "The failure of psychical research should teach us a profound lesson—the lesson that literary training sets limit to the faculties. The leaders of the Psychical Society are literary men." To which Mr. Andrew Lang spicily replied, in an article in the *London News,* entitled "On a certain condescension in scientific men, showing that literary training is not alone in limiting the faculties."

At one time he was interested in psychical research and became a member of the American branch of the English Psychical Society. Some years ago *London Nature* published a series of simple diagrams which were supposed to sustain the theory of thought transference. The experiments consisted in one resting his hand on the head of another person, at the same time concentrating his thought on some simple design. The recipient, with pencil in hand and thought in abeyance, draws a figure on paper. The percentages of similarities were so great in a large number of cases that it was believed that here, at least, were evidences of thought transference. Dr. Minot immediately became interested in the subject and issued five hundred postal cards asking the recipient to draw ten simple figures and return. These were widely distributed, and when these designs were finally tabulated it was found that there was an enormous preponderance of a few figures, such as circles, squares, crosses, etc. From the results of these experiments, embracing five hundred observations, Dr. Minot says: "The general conclusion is unavoidable, that none of the experiments heretofore published afford conclusive evidence of thought transference."

In a report on the prevalence of superstition, Dr. Minot sent out five hundred circulars requesting an answer to four questions relating to—1st, sitting down thirteen at table; 2d, beginning a voyage on Friday; 3d, seeing the new moon over the left shoulder; 4th, occupying a haunted house. The answers were tabulated as to sex, age, etc., and it was found that one in ten men and two in ten women were superstitious.

In all his essays one is impressed with his insistence on the necessity of absolute accuracy in statement. Personal experiences are agreeably introduced which enliven the pages otherwise intensely technical. The last time he met the Swiss naturalist Kolliker, who, he adds parenthetically, was a leader in microscopical research for sixty-five years, was at the International Congress at Rome, in 1894. He says: "It was most impressive to see all the members of the congress spontaneously rise to their feet when the handsome old man unexpectedly entered the meeting."

His tributes to the memory of Bowditch, Leidy, and others are models of appreciative delineation. The salient characteristics of their lives are defined, the important discoveries are clearly mentioned, and particularly the humanity and gentleness of their characters are described with a loving and sympathetic touch, a reflection of his own sweet nature.

It is a rare event when one finds in biological papers the use of algebraic formulæ; yet, in a paper on "Growth as a function of cells," Dr. Minot uses these formulæ with the freedom of a mathematician. The titles of some of Dr. Minot's communications were somewhat startling.

At the Cincinnati meeting of the American Association for the Advancement of Science, he asked the question in a title, "Is Man the Highest Animal?" and proceeded to show that structurally many mammals surpassed man in complexity of structure. In other words, if an intelligence in Mars should land on the earth and discover the skeletons of man in the forest, applying our categories of classification, he would be forced to place man low down in the mammalian scale, though wondering at the large brain-case. The data that Dr. Minot arrayed in support of his thesis aroused a keen and somewhat bitter discussion, as evolution was considered at that time a heresy.

Louis Agassiz always urged his special students never to work up a subject without abundant material for study, and, above all, to find out what other investigators had done on the subject before publishing. A reference to Dr. Minot's publications indicates that he followed implicitly this dictum of Agassiz. The frequent references, quotations, and footnotes show how intimately he had mastered the literature of the subject. He must have been a great reader of scientific memoirs, judging from the numerous citations in his works, and one marvels how he found the time to read the general works of Lecky, Carlyle, Huxley, Darwin, Tyndall, Lubbock, Tylor, and others as well as the works of the principal novelists.

Mrs. Minot told me that Dr. Minot not only read at night, but attending the symphony concerts, he always had a book with him, and at pauses, or at the performing of a work he was not interested in, he would open the book. He was always frank at admitting his incompetence or unfamiliarity with the subject upon which he was writing. Thus, in his article on the "Study of Zoölogy in Germany," after giving an interesting description of German methods, he says: "There are, of course, grave defects connected with the system, but these the author cannot enter into, not being qualified."

In his memoirs on "Senescence and Regeneration," in the *Journal of Physiology,* Vol. XII, No. 2, abounding in plates, tables, and curves, Dr. Minot selected the growth of guinea-pigs for statistical study. "Various considerations led to the selection of this animal. It bears confinement well, is robust and but little liable to disease, breeds readily, is easily managed and fed, and gentle when handled. Its maintenance is much less costly than a larger animal—an important consideration, as one hundred were kept for several years." (The investigation was abruptly brought to an end by the ravages of a dog, who got entrance to their bins and killed 96 in one night.) In a foot-note he adds that "during one winter they consumed upward of 18 barrels of carrots, three tons of hay, 26 bushels of oats and some other food." Illustrating his kindness of heart, he says, "Guinea-pigs are so unintelligent that I have been unable to feel any interest except scientific in them, which has also perhaps been advantageous."*

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* I can appreciate his feelings, for many years ago I was interested in the development of the auricular bones of the cat, and secured several litters of kittens to experiment upon. I sacrificed a kitten every week, and on the fourth week I had become so fond of them that it was difficult to make a selection, and they were trooping through the house like cavalry, and finally had to be disposed of in one fell swoop.

In his vice-president's address before the American Association for the Advancement of Science (Indianapolis meeting, p. 271), "On Certain Phenomena of Growing Old," he calls attention to the law of variation in the physical world, and as an illustration collects in a given area a large number of pebbles on a beach and, measuring each pebble, gives the mathematical curve alike on both sides, each beach varying, of course, yet the curve being of the same nature, and this holds good in all; and he says: "All physical variations which are produced by the common action of a large and varying number of causes existing in an infinite number of degrees presents this same peculiarity in the distribution of the variations." Then he gives curves representing the age of students entering Harvard during a period of twenty years. By studying the changes in cell-growth he shows that with increasing age the cell increases its protoplasmic contents. Seventeen years after this address he gave a course of six Lowell lectures on the subject. At the same meeting (p. 341) he presented a paper on the morphology of the blood corpuscles, showing that they arose from cells.

In his presidential address before the American Society of Naturalists (*Popular Science Monthly,* May, 1895) he discourses on "The Work of the Naturalists of the World" and emphasizes the dignity and importance of the naturalist's work. In this address aphorisms abound, as in many of his writings. A most interesting and valuable collection could be made which would form a volume by itself. Here are a few from this address: "Some persons advocate restriction of the right to vote, but to me restriction of the right to be a candidate offers a practical solution of the problem." "We do not admit that scientific work requires a peculiar mind, but only the cultivation of those fundamental faculties of observation and induction which every one should possess and use." "We are handicapped by the college tradition of four years' education to fit a man for anything in general and nothing in particular."

In his experiences as a student and teacher he associated with men of the highest distinction. At the Massachusetts

Institute of Technology, from which he was graduated the youngest member of his class, he came under the influence of the late Edward C. Pickering, the distinguished astronomer, who at that time was professor of physics. He worked for a time with Louis Agassiz at Cambridge, and later at Agassiz's summer school at Penekese. He had the unrivaled privilege of associating with Henry P. Bowditch in his physiological laboratory at Harvard. "Dr. Minot enjoyed Dr. Bowditch's sympathy, interest, and appreciation, to which he responded with life-long respect and admiration. They published a joint paper in 1874."

Abroad he worked in Carl Ludwig's laboratory. In later years he referred to Professor Ludwig as the greatest teacher of the art of scientific research that he had ever known. He studied at Leipzig in the laboratory of the distinguished Rudolph Leuckart, the founder of the modern classification of animals. He then went to Paris, in the spring of 1875, and pursued his work under Prof. Leon Ranvier. After three years' work with these great men, he returned home. At Seal Harbor he enjoyed long walks with Dr. Charles W. Eliot, an education by itself. With Professor Sargent, in similar jaunts, he doubtless discussed the question of athletic training.

In 1883 he was appointed instructor in histology and embryology in the Harvard Medical School He was later promoted to full professorship, when was published his renowned work upon "Human Embryology." This remarkable work was published by William Wood & Company in 1892. A German edition appeared in 1894. It was dedicated to Carl Ludwig, professor of physiology at the University of Leipzig. The work consisted of 815 pages, illustrated by 463 figures, many of the most intricate character and mostly from his own preparations. Of this work Dr. His, the leading anatomist of Germany, expresses the opinion that "Minot's work at present is the fullest embryology of man which we possess, and it will retain its value as a bibliographical treasure-house even after its contents in any parts have been superseded."

Recently the request has been made for permission to publish a Chinese translation of certain portions of it.

In the short preface of this *magnum opus* he says: "In making my compilation I have drawn constantly from the embryological manuals of Kolliker, Oskar Hertwig, Balfour, and Duval; from the researches of W. His, and from the writings, especially the "Entwickelungsgeschichte der Unke," of Alexander Goette. His modesty is shown in the preface by saying: "The reader will find, nevertheless, imperfections of which I am conscious, and perhaps errors for which I must be responsible. There is probably not a page which might not be corrected with facts already recorded by investigators; certainly not a page which would not be improved by further revision."

While connected with the Harvard Medical School he published a paper in the *Harvard Graduates' Magazine* entitled "On Unsymmetrical Organization," in which he tabulated the appropriations made to the different departments of Harvard University and showed that while one-fifth of the student body was medical, only one-eighteenth of the appropriations went to the Medical School.

Dr. Minot's "Government Report on the Cotton Worm," in conjunction with Edward Burgess, and his "Government Report on the Locust and Cricket," illustrated by a number of plates, indicate his great ability as a draftsman.

The *Philadelphia Medical Journal* published a contribution of Dr. Minot on the unit system of laboratory construction in which he points out the advantages of a unit system of rooms, tables, lighting and all the appliances for study and research.

In *The Microscope* for 1888 he published a paper entitled "The Mounting of Serial Sections," in which he describes his experiences in the difficult technique of staining, cutting, and mounting ribbons of sections for microscopical work. He invented a new form of microtome which was manufactured and extensively used. His mechanical ability aided him greatly in his delicate work with the microscope.

The great collection of sections of vertebrate embryos and tissues in the Harvard Medical School is almost encyclopedic in character and an illustration of Dr. Minot's nicety and precision which marked all his endeavors. The collection consists of thousands of vertebrate embryos, mostly those of man, cut in three different sections—longitudinal, transverse, and frontal—and classified and numbered with the minutest accuracy, and forms a lasting monument to his untiring patience and skill. The cases in which the slides are arranged, methods of numbering, cataloging, and other details were all devised by Dr. Minot. Superadded to his attainments in science, Dr. Minot's accomplishments were varied in other directions. He showed great skill as a draftsman, and his anatomical drawings made under the microscope were clear and accurate. He was also talented as a water-color artist, and some of his landscapes might be mistaken for those of a professional. His skill in establishing new varieties of peonies was marked, and he won the highest prizes from the Massachusetts Horticultural Society year after year.

That his achievements were promptly recognized is attested by the many honorary degrees he received from home and foreign universities. From Yale he received the degree of Doctor of Laws, in 1899; from Oxford, Doctor of Science, in 1902; from Toronto University, Doctor of Laws, in 1904, and from St. Andrews, Doctor of Laws, in 1911.

Dr. Lewis, in his memoir of Dr. Minot, says: "In his exchange professorship with Germany, in 1912-13, he represented not only Harvard University, but the anatomists of America, and he took no less pleasure in presenting the work of his colleagues than in describing his own researches." In this exchange he lectured at the universities of Berlin and Jena.

On June 1, 1889, Dr. Minot was married to Miss Lucy Fosdick, of Groton, Massachusetts. Refined and cultivated, she formed a fitting companion for this busy naturalist. She keenly appreciated the varied works of her husband and aided him in many ways. At her summer residence in Readville she has kept up the wonderful garden of peonies which Dr.

Minot started, and friends and neighbors are freely invited to enjoy its beauties.

In the preparation of this brief memoir I am indebted to Mrs. Minot, who placed in my hands a complete collection of her husband's writings. I have also been aided by the memoirs of Dr. Minot, by Dr. Frederic T. Lewis, *Boston Medical and Surgical Journal,* Vol. CLXXI, p. 911, and the *Anatomical Record,* Vol. 10, No. 3; Prof. Henry H. Donaldson, Proceedings of the Boston Society of Natural History, Vol. 35, No. 2, and *Science,* N. S., Vol. XL, p. 926; Dr. Charles W. Eliot, Proceedings of the Boston Society of Natural History, Vol. 35, No. 2; Dr. W. T. Councilman, Proceedings of the American Academy of Arts and Sciences, Vol. 53, No. 10, and Dr. J. L. Bremer, the *Harvard Graduates' Magazine,* Vol. XXIII, No. XCI.

A glance at Dr. Minot's extensive bibliography, compiled by Dr. Frederic T. Lewis, shows the depth and dignity of many of his titles. The range of subjects dealt with in his various memoirs, presidential addresses, and communications include anatomy, physiology, zoölogy, histology, pathology, embryology, morphology, psychology, toxonomy, and microscopical technique, besides articles on general subjects, and his crowning work, "Human Embryology."

Dr. Frederic T. Lewis, in his address on Dr. Minot before the American Association of Anatomists, gives a very full bibliography of Dr. Minot, and this I have used. Dr. Lewis has sent me four additional titles and I have added a note from the Proceedings of the Boston Society of Natural History, which carries the record back to 1868.

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